RADIOLOGY

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THE DISTRIBUTION OF RADIATION WITHIN THE AVERAGE FEMALE PELVIS FOR DIFFERENT METHODS OF APPLYING RADIUM TO THE CERVIX[1]

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NO single plan of irradiation is suitable for the treatment of all patients with cervix cancer: in each instance there must be some individualization of the case. However, it is always desirable to deliver radiation in a manner that will produce as small an amount of damage to normal tissues as is consistent with adequate treatment of the tumor-bearing region. Despite the fact that conditions vary with individuals, there are certain procedures that can be followed in the administration of roentgen rays, which will deliver a distribution of radiation suitable to the treatment of most patients. Data for these procedures were given in a previous paper (1), in which diagrams were published, showing the distribution of roentgen radiation within the average female pelvis for several arrangements of skin fields. Each plan studied was one which might be considered practicable in most radiologic departments, and was shown for target-skin distances of both 50 and 70 centimeters. Radiation was delivered by a 200 kv. x-ray machine, with 0.5 mm. Cu and 2.0 mm. Al filter. An arrangement employing six fields, with a target-skin distance of 70 cm., was found to deliver the most satisfactory distribution of radiation.

For this particular technic, two fields were used on the anterior surface, two on the posterior, and one on each lateral aspect of the pelvis. All the irradiated skin areas were of the same size, 15 cm. longitudinally and 10 cm. transversely. It was found that fields of these dimensions would extend from the level of the iliac crests to the middle of the symphysis pubis on most patients. These bony landmarks can be used for marking out skin portals in any position in which the patient may be placed. Radiographic studies showed that both the promontory of the sacrum and the cervix were included within the direct beams.

On the anterior and posterior surfaces the fields were separated in the mid-line by a distance of 2 centimeters. Each beam was directed straight into the pelvis toward the underlying parametrium, and was not tilted toward the mid-pelvis. By this means both the bladder and rectum are spared doses in excess of the amount delivered to the cervix. Lateral beams do not contribute much radiation to structures at depths as great as the middle of the pelvis, but they do increase the total dose obtained in the parametrial regions, to such a degree that it actually becomes greater than the full amount of radiation delivered to the cervix. The distribution of radiation within the average pelvis with the chosen method is shown in Figure 1.

[1] Presented before the Radiological Society of North America, at the Twenty-first Annual Meeting, in Detroit, Dec. 2–6, 1935.

This distribution of roentgen radiation is suitable for the treatment of cervix cancer, not only because of the protection afforded the bladder and rectum, but also because the parametrial regions receive a greater dose than the cervix. Radium applied to the cervix will control the disease in the primary lesion in most instances, but will not deliver a lethal dose to a tumor located at a distance greater than three or four centimeters from the cervical canal. External irradiation must be relied upon to treat adequately parametrial and outlying tumor-bearing regions. It is unlikely that patients would tolerate the amount of roentgen radiation required to deliver the same dose to the parametrial regions as is obtained throughout most of the primary lesion from radium applied to the cervix. However, when both radium and x-rays are employed, one supplements the other so that the total volume of tissue receiving a lethal dose is increased. Since no detailed consideration was given to radium applied to the cervix in the previous publication, it was considered desirable to extend the work for this purpose. The distribution of radiation obtained from several methods of applying radium will be studied. Each application will be shown within a diagram of the uterus and bony pelvis. The one found to be the most desirable will be illustrated in combination with x-rays delivered through six fields with a target-skin distance of 70 centimeters.

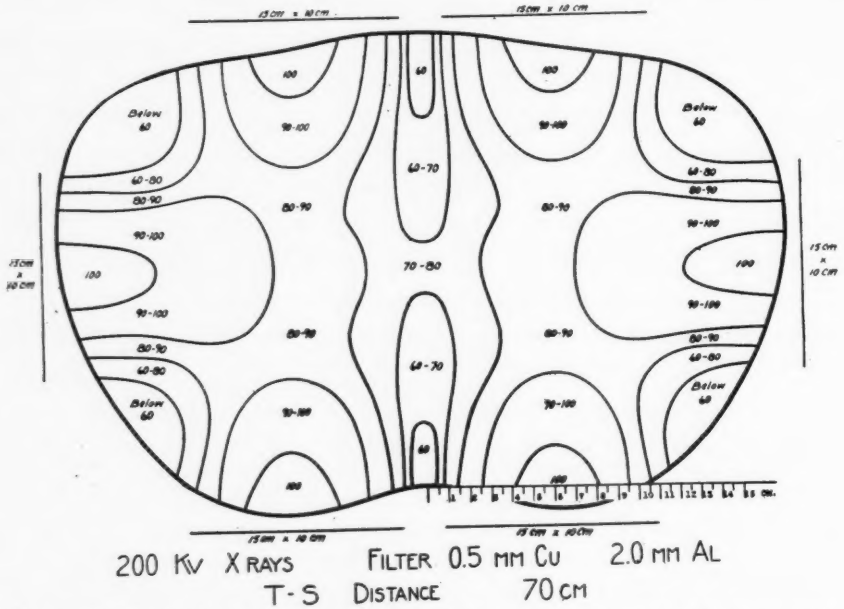

Fig. 1. The distribution of roentgen radiation within the average female pelvis for six fields measuring 15 × 10 cm. each, and arranged in the manner shown.

The outline of the bony pelvis used in each diagram has been determined from the measurements given for the average female pelvis by Williams (2), and Davis (3). Since most patients with carcinoma of the cervix have borne children, the size of the uterus (8.0 × 5.0 × 3.5 cm.) was determined from data given for multiparous uteri by Williams and Davis.

The various diagrams will be compared to determine the differences in the distribution of radiation obtained from the various methods of applying radium to the cervix. The measurements of the bony pelvis do not vary sufficiently to cause any problem in representing the average patient. Neither are variations in the size of the

uterus of great importance, because the dimensions used in the diagrams represent an average multiparous uterus not complicated by special conditions such as myomas, or other pelvic diseases. In practice, the position of the uterus, and the gross character of the cervical lesion will vary considerably in various patients. However, for the sake of comparison, certain conditions must be assumed to be constant. It will readily be seen that the data here given can be applied to other cases, when the position of the uterus and size of the lesion are known. The uterus has been shown as lying in a plane almost parallel to the patient's length, because it will usually assume a position of moderate retroflexion when the patient is lying in bed, with radium placed in the canal and with the vagina packed. The primary lesion has been represented as one in which the cervix is not destroyed, and measures 3 cm. in diameter. The fornices have been assumed to be free from disease, so that radium could be placed lateral to the cervix.

In comparing the diagrams, it is not only necessary that they be constructed upon comparable anatomical conditions, but also that approximately equal total doses of radium must be used in order to illustrate any improvement in the distribution of radiation obtained from one particular method of application over another. The distribution of radiation obtained from an intra-uterine tandem for a dose of 3,000 mg.-hr. will be considered first. In studying methods for improving the distribution of radium radiation, the tandem will be shown for a dose of 5,000 mg.-hr., and in combination with other sources of radiation (such as needle, bomb, plaque, and colpostat) for total doses of from 4,500 to 5,000 milligram-hours.

Some of the methods illustrated for applying radium to the cervix may be similar to the methods followed by certain individuals, but found to differ in the doses delivered by the various sources of radiation. Technics advocated by other authors cannot always be followed accurately in the diagrams, because these have been prepared to compare the distribution of radiation obtained from various methods of applying a given amount of radium to the cervix. Data upon the distribution of radiation obtained from particular methods and specified doses have been published by Schmitz (4), Healy (5, 6), Mallet and Coliez (7), and others. It is intended that by comparison of the diagrams presented here, the method most suitable in the average case can be determined. Obviously no particular application can be advocated as a routine method of treatment for all patients with cervix cancer; a procedure adaptable to one may be impractical for another.

It has already been stated that some diagrams will demonstrate the distribution of radiation obtained from both radium and x-rays. In such instances it is necessary to employ some unit that can be used for expressing the combined amount of radiation delivered by the two sources. If, in addition to x-rays, several sources of radium radiation are used for varying doses in the same patient, it is impractical to express the combined amounts of radiation delivered to a given point at a particular depth in terms of percentages of the surface dose. The so-called threshold erythema dose serves very well for a unit. This has been defined by Quimby (8) as representing an amount of radiation which, given at a single exposure, will produce a visible reddening or bronzing of the skin in 80 per cent of the individuals within four weeks after receiving the dose, and no visible reaction in the remaining 20 per cent. While the definition originally related to external irradiation by x-rays or radium, it has been extended by Martin and Quimby (9) to interpret doses from interstitial sources of radium, such as seeds, needles, tandems, etc.[2]

[2] The threshold erythema dose is approximately 525 roentgens (air) for 200 kv. x-rays, with 0.5 mm. Cu filter, and a skin field measuring 10 × 10 cm. For other fields it may be determined in accordance with data on the effect of size of field on tissue dose. (Failla, G., and Quimby, E. H.: The Economics of Dosimetry in Radiotherapy. Am. Jour. Roentgenol. and Rad. Ther., 1923, **10** 944–967). The threshold erythema dose for radium is about 225 mg.-hr. for a tube 2 cm. long at a distance of one centimeter. Data are given for other sources or distances in a paper by Quimby (14).

It is impractical to show differences of a single threshold erythema dose on the diagrams, because of the great intensity near the source of the radium radiation, and the rapid decrease in the percentage depth dose a few centimeters away. In any case the estimation of tissue dose can be only approximate. Since it is necessary to demonstrate the distribution of radiation by showing differences of several erythemas, it is desirable to group the threshold erythemas according to a greater or lesser amount than the suspected lethal dose for cervix cancer. Data presented in collaboration with Healy (10), and Stewart (11), indicate that in most instances a minimum dose of from six to eight threshold erythemas, distributed throughout the primary lesion, is required to destroy completely the disease in the cervix and to prevent its recurrence. In the diagrams presented here the minimum dose indicated is from one to four threshold erythemas. It is doubtful that this amount of radiation would be very effective in destroying the disease. The distribution of from four to seven threshold erythema doses is shown, which represents an amount of radiation that would be expected to produce marked changes in the tumor. The volume of tissue that receives from seven to fifteen threshold erythema doses is also indicated in each diagram; within this region the disease should surely be destroyed. Finally, the volume of tissue that receives doses in excess of 15 threshold erythemas is shown. Sloughing and necrosis may occur in these regions.

For the preparation of the diagrams it was first necessary to make several charts showing isodose curves about given sources of radium radiation. Each chart was for a particular source of radiation, and showed the distribution of threshold erythemas for a specified dose. The isodose curves were usually drawn in a plane parallel to the length of the capsule, tube, needle, etc. However, in some instances it was necessary to show also the distribution of threshold erythema doses in a plane transverse to the middle or around the end of the source of radiation. Data for the various isodose charts were taken from several publications: Quimby (12, 13, 14), Quimby and Stewart (15), Martin and Quimby (9), and Laurence (16). Data for the bomb shown in one diagram were obtained from publications by Healy (5, 6). In every method studied, the radium filter was considered to be equivalent to 2 mm. brass.

Diagrams shown here, illustrating the distribution of threshold erythema doses for several methods of applying radium to the cervix, were prepared by placing the proper isodose chart in the correct position for treatment, under an outline of the uterus and bony pelvis drawn on transparent paper. The contribution from each source of radiation was noted at various points within the pelvis, and the sum of all these calculated for each point. Lines drawn through points receiving the same total radiation divide the pelvis into regions receiving specified doses. Such lines were drawn for total amounts of radiation corresponding to one, four, seven, and 15 threshold erythema doses. For combining radium and x-rays, data were obtained from the publication (1) already referred to. The dose of roentgen radiation delivered to each skin field will be discussed when diagrams showing the combination of the two types of radiation are considered.

For comparing the relative value of the different methods of applying radium to the cervix, several factors are to be considered. The amount of radiation delivered throughout the cervix must be sufficient to control the disease in the primary lesion. However, too great a dose may produce a persistent radiation ulcer, which is apt to give rise to various complications. The dose delivered to the parametrial regions should also be noted, as well as the amount of radiation reaching the bladder and rectum. Therefore, in comparing the diagrams illustrating the various methods, it is desirable to note the volume of tissue receiving specified doses in each instance. This can be done by considering the distance lateral to the intrauterine tandem that a given dose is indi-

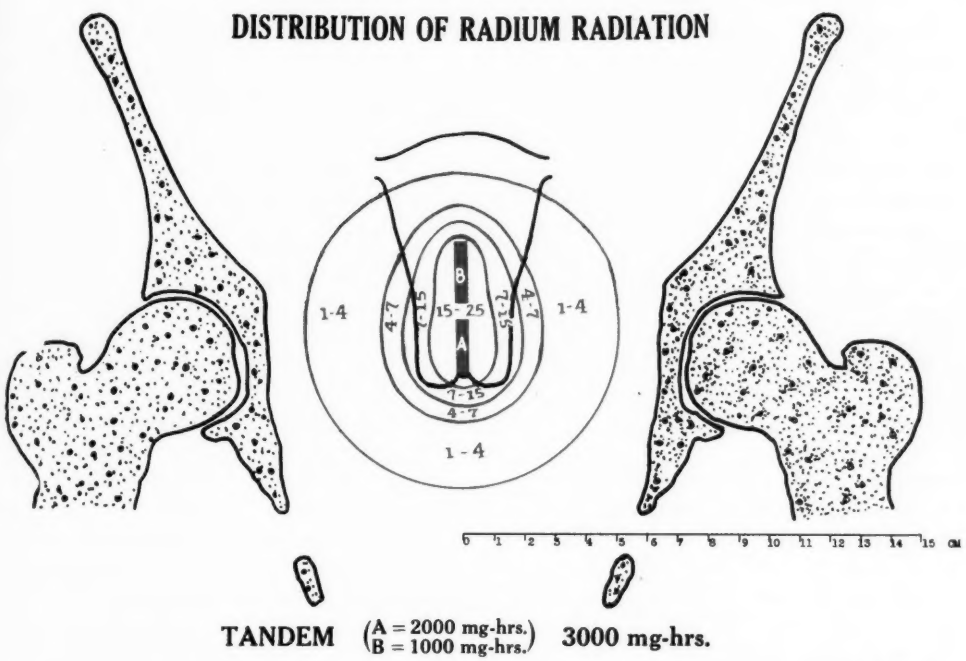

Fig. 2. The distribution of radium radiation within the average female pelvis for an intra-uterine tandem consisting of two capsules, for a dose of 3,000 mg.-hrs.

cated by the isodose curves. For amounts of radiation distributed throughout the cervix, measurements will be made in a transverse plane extending laterally from a point corresponding to the center of the lower capsule in the tandem. This plane will be, therefore, about one centimeter above the external os. In considering parametrial doses, measurements will be made in a transverse plane extending laterally from a point corresponding to the middle of the tandem, which will be about 2.2 cm. above the external os. By such a comparison it will be possible to demonstrate the value of certain methods in delivering greater amounts of radiation to the parametrial regions, without over-irradiating the primary lesion.

Not only must the distribution of radiation throughout the tumor-bearing region be considered, but attention must be given also to the dose delivered to the bladder and rectum. In many instances these regions are not infiltrated by the disease, and must be protected from excessive doses. A method of applying radium that will minimize the quantity delivered to these structures, and yet deliver a suitable dose to regions that harbor disease would be the most desirable.

INTRA-UTERINE TANDEM WITHOUT OTHER SOURCES OF RADIUM RADIATION

In most clinics the tandem used for the treatment of cervix cancer consists of two capsules. A greater amount of radium is usually contained in the cervical end of the tandem than in the portion extending into the uterine cavity. The minimum dose employed is probably about three thousand milligram-hours. In Figure 2 is shown the distribution of threshold erythema doses for 3,000 mg.-hr. delivered by a tandem composed of two capsules, the lower one of which is twice the strength of the upper. Each capsule measures 2 cm. in length, and 4 mm. in diameter.

For a dose of 3,000 mg.-hr. from the tandem described above, 2,000 mg.-hr. would be delivered by the lower capsule, labeled

"A," and 1,000 mg.-hr. by the upper one, labeled "B." Since two-thirds of the total dose is delivered by the lower capsule, the isodose curves near the source of radiation include a greater volume about the cervical portion of the tandem, than they do around the upper end. Isodose curves indicating doses delivered to points farther away from the tandem do not show such a marked effect from the unequal distribution of radium.

Immediately about the tandem is shown a dose of from 15 to 25 threshold erythemas. This amount of radiation may be expected to produce necrosis and sloughing, and extends laterally from the center of the lower capsule for a distance of about one centimeter. The distribution of from seven to fifteen threshold erythema doses, which may be considered a lethal amount of radiation in most instances, is over a volume of tissue that includes all the cervix, and extends into the parametrial regions for a distance of about two centimeters, lateral from the middle of the tandem. From four to seven threshold erythema doses are delivered into the parametrial regions for a distance of only 2.5 cm. from the middle of the tandem. It is unlikely that less than four threshold erythemas would produce any permanent damage to cervix cancer. One threshold erythema dose is delivered into the parametrial regions 5 cm. from the middle of the tandem.

Since the sources of radiation are arranged in tandem formation, the distribution of threshold erythema doses in the anteroposterior diameter would be the same as has been shown for the transverse plane, if the capsules of radium remained in a straight line. Reasons have already been given for assuming in each diagram that the uterus was in a position of moderate retroflexion, lying almost parallel to the patient's length. It may be estimated, therefore, that both the bladder and rectum receive from one to five threshold erythema doses. If there were an acute flexion of the corpus in either a forward or backward direction, there might have been some increase in the bladder or rectal dose directly adjacent to the uterus. In either event, however, the amount of radiation delivered throughout most of the bladder and rectal regions would remain from one to five threshold erythema doses.

As has been stated, it is necessary that each of the various diagrams illustrate the same anatomical conditions, so that a comparison of the relative value of the different methods can be made. In practice, however, there are many variations in the gross character of the lesion in individual cases of cervix cancer. The anatomical conditions illustrated in the diagrams represent a uterus of average size, in which the gross anatomy has not been distorted greatly by the tumor. Such conditions would usually exist only in patients with early disease. In some instances, especially in advanced carcinoma, the cervix might be increased in size, or it might be destroyed. Enlargement of the cervix may be diffuse, or involve only a portion of the organ. Since the size of the isodose regions remains the same in every instance, the distribution of radiation obtained throughout a cervix of greater dimensions could be determined by drawing in the actual size of the particular lesion under consideration. For instance, if disease enlarged the cervix to a diameter of 3.5 cm., it would still receive a minimum distribution of from seven to fifteen threshold erythema doses. This would probably be sufficient to control the disease in the primary lesion in most instances. However, if the diameter were greater, some portions of the cervix would receive only from four to seven threshold erythema doses.

In a number of clinics the tandem has been used for doses in excess of 3,000 mg.-hr. in an attempt to deliver a greater amount of radiation to the adjacent parametrial regions. Newell (17) and Crossen (18) have reported the use of a tandem of 100 mg. for 5,000 milligram-hours. The published statistics indicate that the percentage of five-year survivals will be increased over that obtained for lesser doses.

In Figure 3 is shown the distribution of threshold erythema doses for 5,000 mg.-hr. delivered by a tandem identical to the one

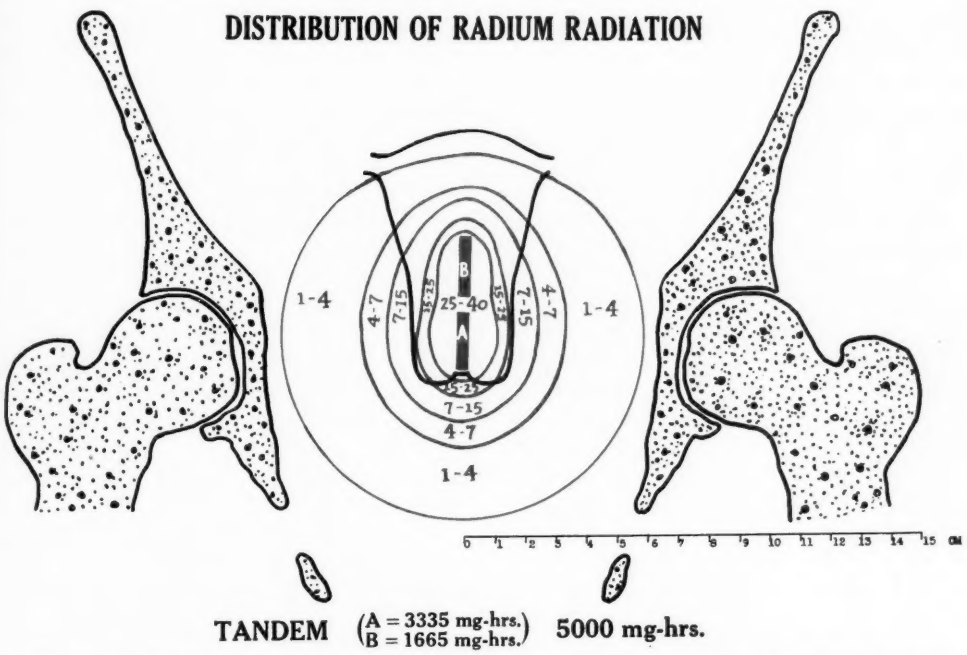

Fig. 3. The distribution of radium radiation within the average female pelvis for an intra-uterine tandem consisting of two capsules, for a dose of 5,000 mg.-hrs.

discussed above. Immediately about the tandem is recorded a dose of from 25 to 40 threshold erythemas. There is a minimum distribution of from fifteen to twenty-five threshold erythema doses throughout the cervix for a distance of 1.5 cm. lateral to the center of the lower capsule. In the preceding diagram for 3,000 mg.-hr., a distribution of from seven to fifteen threshold erythema doses was shown to extend into the parametrial regions for a distance of about two centimeters lateral to the middle of the tandem. For 5,000 mg.-hr. the same dose reaches a distance of only 2.5 cm. from the middle of the tandem. From four to seven threshold erythema doses are delivered about 3.5 cm. away, and one threshold erythema is delivered 6 cm. out into the parametrial regions.

The amount of radiation reaching the bladder and rectum may be estimated in the same manner employed before. Upon this basis it may be said that these regions receive from one to eight threshold erythema doses.

Percentage depth doses for interstitial sources of radiation are lower than those obtained from sources in which some distance intervenes between the radium and the surface to which it is applied. Therefore, if the dose delivered by a tandem is increased considerably, there will be only a slight improvement in the amount of radiation reaching points two or three centimeters away. This can be noted by comparing the two diagrams just mentioned. The use of 5,000 mg.-hr. instead of 3,000 mg.-hr. represents an increase of 66 per cent in the dose delivered by the tandem. There is only a 25 per cent increase in the distance lateral to the middle of the tandem that the supposed lethal dose (from seven to fifteen threshold erythema doses) is delivered into the parametrial regions. For such an increase in the dose delivered by the tandem there is a greater amount of tissue damage at the site of the application of radium. The distance that a dose expected to produce necrosis and sloughing (above 15 threshold erythema doses) ex-

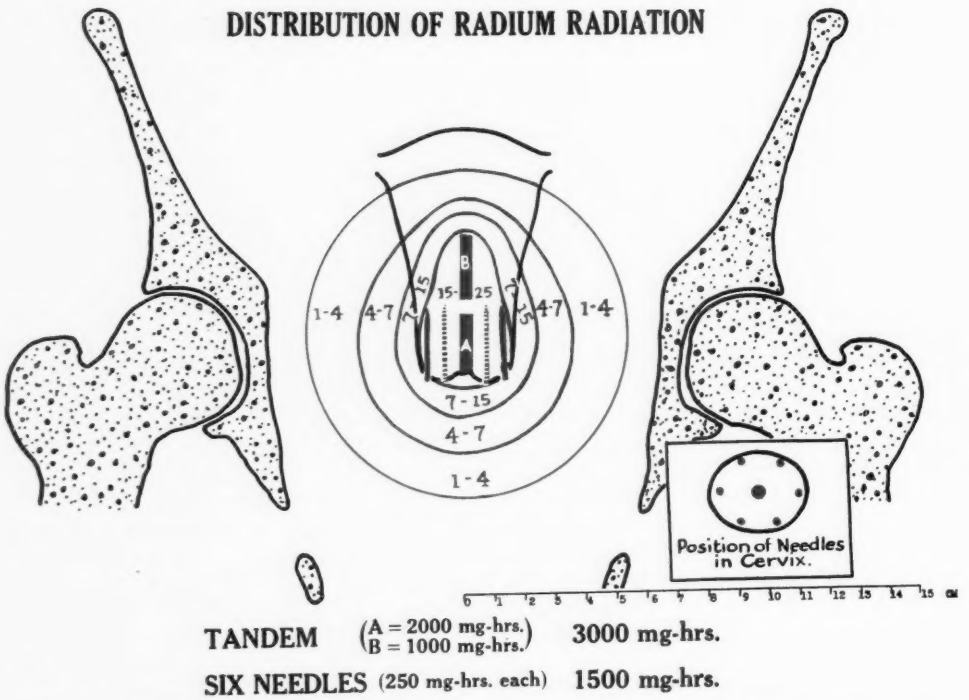

Fig. 4. The distribution of radium radiation within the average female pelvis for an intra-uterine tandem in combination with needles inserted into the cervix.

tends lateral to the center of the lower capsule is increased 50 per cent.

For both the doses mentioned, a volume of tissue surrounding the tandem is over-irradiated. It would be desirable to obtain the improvement in the parametrial dose, without increasing this volume. There would also be an advantage in preventing any tissue from receiving a dose in excess of 25 threshold erythemas. Furthermore, it might be impractical to deliver large doses of roentgen radiation to patients in whom there was already considerable destruction of tissue by radium. External irradiation is of great importance in the attempt to treat adequately disease located beyond the zone of effect of radium applied to the cervix. It should be mentioned that the distribution of threshold erythema doses shown for tandems placed in the uterine canal does not apply to those instances in which radium has been packed into a cratered lesion, or against the cervix, when the canal cannot be located.

INTRA-UTERINE TANDEM COMBINED WITH OTHER SOURCES OF INTERSTITIAL RADIATION

Some authors have reported the use of an intra-uterine tandem in combination with other sources of interstitial radiation. Ward and Sackett (19) have published the description of a technic, in which radium needles are inserted in the periphery of the cervix at the junction with the vaginal fornices. If the entire cervix is involved with disease, needles may be inserted all the way around the cervix.

In Figure 4 is shown the distribution of threshold erythema doses for an intra-uterine tandem in combination with radium needles. A dose of 3,000 mg.-hr. is delivered by the tandem. Six needles of equal strength, inserted about the periphery of the cervix, deliver a combined dose of 1,500

milligram-hours. The total dose from all sources of radiation shown in the diagram is 4,500 milligram-hours. For the specified conditions the needles will contribute a minimum dose of about four threshold erythemas throughout the cervix. They will also deliver from one to four threshold erythema doses to the adjacent parametrial regions. From both the tandem and the needles from 15 to 25 threshold erythema doses are delivered throughout the cervix for a distance of 1.5 cm. lateral to the center of the lower capsule. A dose of from seven to fifteen threshold erythemas is delivered into the parametrial regions for a distance of a little more than 2 cm. lateral to the middle of the tandem. From four to seven threshold erythema doses reach a point about 3.5 cm. out into the parametrial regions, and one threshold erythema is delivered a little more than 5 cm. away from the middle of the tandem.

The distribution of radiation anterior and posterior to the uterus will be essentially the same as has been shown for the lateral plane. Both the bladder and rectum may be expected to receive from one to seven threshold erythema doses. If needles are inserted in the periphery of the cervix only at the junction with the lateral vaginal fornices, the bladder and rectal dose near the uterus will be diminished. However, if the combined amount of radiation delivered by the various needles is decreased, a lesser dose will be delivered to the primary lesion and the parametrial regions.

The insertion of needles into the cervix influences the distribution of radiation throughout the primary lesion more than it does the parametrial dose. For the specified doses from the sources of radiation shown in the diagram, the minimum amount of radiation delivered to the cervix and vaginal fornices is practically the same as was obtained from the tandem alone for 5,000 milligram-hours. Doses above 25 threshold erythemas are avoided. The needles do contribute some radiation to the parametrial regions, but the improvement over the tandem alone for 3,000 mg.-hr. is not quite as great as was noted for 5,000 mg.-hr. from the tandem. For patients in whom there is a bulky cervical lesion, needles may be used to increase the dose in this volume of tissue, instead of delivering excessive doses from the intra-uterine tandem. However, the amount of radiation delivered to the bladder and rectum will be about the same, whether the tandem is used for 5,000 mg.-hr., or needles are employed in the manner shown. In some individuals the bladder may receive a slightly greater dose than the rectum. At the Memorial Hospital, Dean (20) noted that bladder injuries following irradiation for cervix cancer are more apt to occur in patients treated with interstitial sources, than in those who are given an intra-uterine tandem for a dose of about 3,000 mg.-hr. in combination with an intravaginal applicator. The dose delivered to the primary lesion can be increased by means of intravaginal applicators in combination with an intra-uterine tandem. In many instances this procedure may be more practical than the use of interstitial sources.

INTRA-UTERINE TANDEM COMBINED WITH INTRAVAGINAL APPLICATORS CONTAINING RADIUM

The gross character of the primary lesion in cervix cancer presents such a variety of forms that no particular intravaginal applicator is suitable for the treatment of all patients. Several types of applicators have been described by Healy (5, 6), and Heyman (21), for placing radium against the surface of the various types of cervical lesions. The one most frequently employed by Healy has been the so-called "bomb," the shape of which may be compared to an egg, except that the irradiating surface is flat. Radon is contained inside the applicator so that a radium-skin distance of about 1.2 cm. is provided. Lead walls of the bomb reduce considerably the amount of radiation reaching surrounding tissues, except in the direction of the primary beam used for treatment, which is 1.5 cm. in diameter at the surface.

The bomb can be applied in any of three

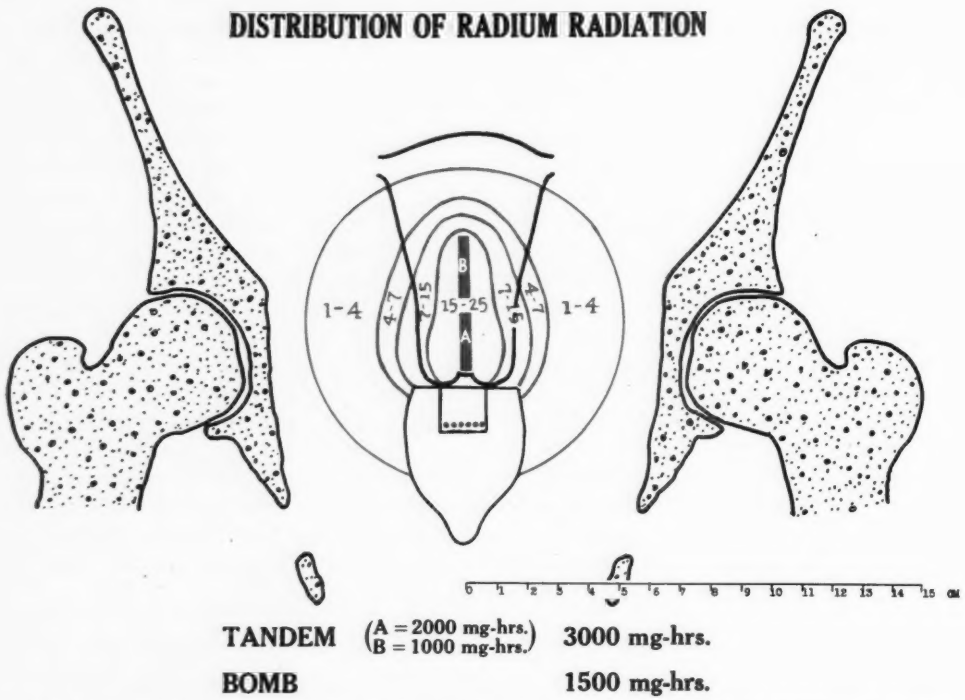

Fig. 5. The distribution of radium radiation within the average female pelvis for an intra-uterine tandem in combination with a bomb placed against the cervix.

positions, so that the beam is directed toward the cervix, or into the right or left lateral fornix. Doses of 1,000 mc.-hr. to 1,500 mc.-hr. are usually given for each application. It was found that the use of the bomb in all three positions, in combination with an intra-uterine tandem for 3,000 mg.-hr., delivered too great an amount of radiation in most instances. Because of the severe reactions, during the past several years Healy has generally used the bomb only against the cervix.

In comparing methods for applying radium to the cervix, it is impossible to consider all the various conditions with which one is confronted in the treatment of cervix cancer. Neither is it practical to discuss the various procedures that may be followed by a particular individual to obtain the most satisfactory distribution of radiation for each patient. Of all intravaginal applicators the bomb is perhaps the most easily used. The difficulties encountered in placing radium against the cervix may be so great in some patients that only the bomb can be introduced into the vagina. In such instances it is usually impossible to place the applicator in any position other than straight against the cervix.

In Figure 5 is shown the distribution of threshold erythema doses for the bomb placed against the cervix for a dose of 1,500 mg.-hr., in combination with an intra-uterine tandem for 3,000 milligram-hours. It has been shown in this position so that a comparison can be made with other procedures in which radiation is delivered into the lateral fornices.

Most of the radiation delivered by the bomb, in the position shown, is contributed to a volume of tissue that receives a greater dose from the tandem. For the specified conditions, the bomb delivers from one to three threshold erythema doses to this region. The change produced in the isodose curve surrounding the tandem is not as

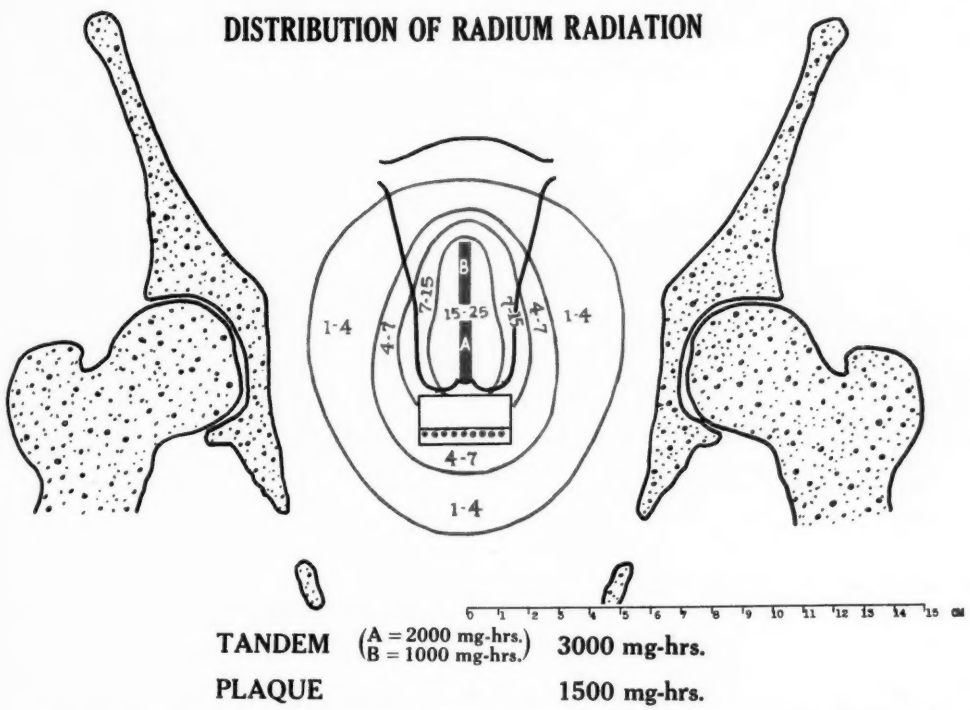

Fig. 6. The distribution of radium radiation within the average female pelvis for an intra-uterine tandem in combination with a plaque placed against the cervix.

marked as for the curves indicating lesser doses. The volume of tissue in the primary lesion and vaginal fornices, throughout which the supposed lethal dose is delivered by the bomb and tandem combined (from seven to fifteen threshold erythemas), is practically the same as that noted in the diagram illustrating the use of needles. The parametrial dose shows only a slight improvement over that obtained from the tandem alone for 3,000 milligram-hours. The bladder and rectal regions may be estimated to receive from one to six threshold erythema doses.

Another intravaginal applicator that is employed frequently is the so-called plaque. These applicators may be of various sizes, and, like the bomb, can be used for delivering radiation to the cervix, or vaginal fornices. If a plaque is placed directly against the lesion, the distance between the radium and the surface to which it is applied will be only a few millimeters. In such instances the percentage depth dose will be lower than for the bomb. The percentage depth dose can be increased by lengthening the radium-skin distance with rubber, cork, or some other organic material, placed on the irradiating surface.

In Figure 6 is shown the distribution of threshold erythema doses for an intravaginal plaque, measuring 3 × 2 cm., in combination with an intra-uterine tandem. The plaque is shown directly against the cervix for a dose of 1,500 mg.-hr., with a radium-skin distance of one centimeter. The tandem dose is 3,000 mg.-hr., as usual.

As was noted for the bomb, the plaque delivers from one to three threshold erythema doses to the cervix, and adjacent tissues. The distribution of radiation throughout the parametrial regions is practically the same as that shown for the bomb. The dose delivered throughout the

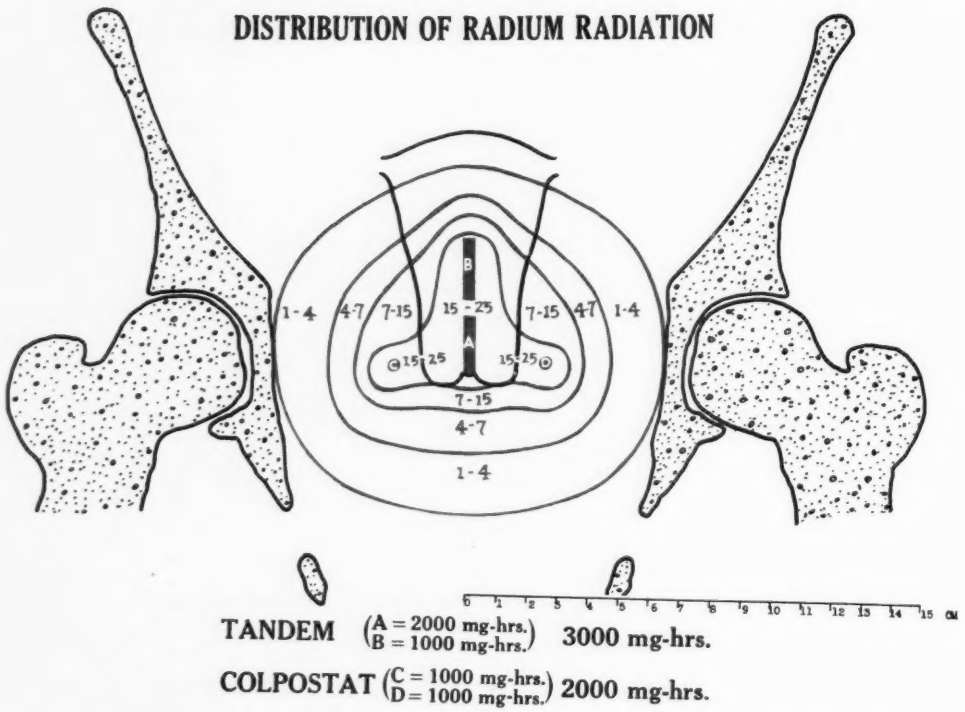

Fig. 7. The distribution of radium radiation within the average female pelvis for an intra-uterine tandem in combination with sources of radiation located in the lateral vaginal fornices by means of a colpostat.

primary lesion and adjacent vaginal fornices is also about the same, except that the isodose curves indicating less than seven threshold erythemas include a greater volume of tissue near the level of the plaque. This is due to the fact that the wall thickness of the average plaque is only a few millimeters. Radiation is, therefore, delivered in all directions. For the bomb there is a beam of radiation that is controlled by the thick lead walls of the applicator. In most instances the radiation delivered through the walls of the plaque would be directed toward normal structures. This will tend to increase the amount of radiation reaching the bladder and rectum. These regions may be estimated to receive from one to approximately seven threshold erythema doses.

It is evident that intravaginal applicators placed against the cervix do not alter materially the distribution of radiation in the parametrial regions. If anatomical conditions permit an application that will direct radiation toward the parametria, the doses delivered to these regions will be increased. Furthermore, if sources of radiation can be placed well out in the lateral vaginal fornices, the parametrial dose may be increased, without contributing very greatly to the amount of radiation reaching the bladder and rectum.

An intravaginal applicator used for placing sources of radiation lateral to the cervix is the so-called colpostat. This applicator consists of two cork, or rubber, containers, held together by means of a metal support. Both containers hold a capsule of radium, one being placed in each lateral fornix. The distance between the center of the capsule located in the fornix, and the lower part of the intra-uterine tandem, will vary with conditions. The distribution of radiation that is obtained from such an applica-

tion is influenced more by this distance, than it is by the position in which the capsules are placed. That is, for identical doses and distances, the distribution of radiation will be essentially the same, whether the capsules in the fornices are parallel, or at right-angles to the tandem.

Since the radium located lateral to the cervix is held in a container of organic material, the capsule does not come in direct contact with the mucosal surface. For such an applicator, therefore, a radium-skin distance is provided that is equivalent to the thickness of the wall of the container. This may be from 0.5 to one centimeter. It should be mentioned that the colpostat is an applicator that is best suited for patients with a fairly roomy vagina, in whom the fornices are not obliterated by the disease. If the diameter of the vaginal tube is diminished, or if the fornices are infiltrated so that they cannot be expanded, it may be very difficult to place a colpostat in the correct position.

In Figure 7 is shown the distribution of radiation for a colpostat in combination with an intra-uterine tandem. The capsules located in the fornices lie in a plane parallel to the anteroposterior diameter of the patient, which is at right-angles to the intra-uterine tandem. The distance between the center of each capsule in the fornix, and the middle of the cervical portion of the tandem, is 2.5 centimeters. The two sources of radium lateral to the cervix are, therefore, 5 cm. apart. If a radium-skin distance of 0.5 cm. is used, the vagina will have to be distended to a transverse diameter of 6 centimeters. This can probably be accomplished in most patients. Each capsule in the intravaginal applicator is shown for a dose of 1,000 milligram-hours. The intra-uterine tandem is illustrated for 3,000 milligram-hours. The total dose from all sources of radiation included in the diagram is 5,000 milligram-hours.

The entire cervix receives from 15 to 25 threshold erythema doses. This amount of radiation extends lateral to the center of the lower capsule of the tandem for a distance of a little more than three centimeters, However, the region lateral to the cervix, throughout which such a large dose is distributed, is confined chiefly to the volume occupied by the colpostat itself. From seven to fifteen threshold erythemas are delivered into the parametrial regions for a distance of almost 3.5 cm. lateral to the middle of the tandem. From four to seven threshold erythema doses are delivered about one centimeter further, and one threshold erythema reaches the pelvic wall, which is 6.5 cm. away.

The distribution of radiation anterior and posterior to the uterus is quite different from that which has been shown in the transverse plane. From a diagram not included here, it may be estimated that the bladder and rectal regions receive from one to seven threshold erythema doses.

The diagram shown for the colpostat illustrates the importance of delivering radiation through the vaginal fornices, whenever anatomical conditions permit such a treatment. By this means the parametrial dose can be increased materially, without delivering excessive doses from any particular source. If the sources of radiation in the lateral fornices are located at a considerable distance from the intra-uterine tandem, they do not contribute greatly to the dose delivered to the bladder and rectum. A method which would deliver a beam of radiation toward the parametrial regions (such as the intravaginal bomb directed toward the fornices), would afford even greater protection to the bladder and rectum.

DISCUSSION

No single method that has been illustrated for applying radium to the cervix is suitable for the treatment of all patients. Neither are the doses specified in any instance to be advocated as a routine for a particular technic. Every case of cervix cancer must be individualized, and the treatment planned accordingly. The data given for each of the methods may be applied to any given patient by drawing in the proper outline of the lesion and uterus

TABLE I. A COMPARISON OF THE DISTANCES LATERAL TO THE INTRA-UTERINE TANDEM THAT SPECIFIED DOSES ARE DELIVERED, AND THE AMOUNT OF RADIATION REACHING THE BLADDER AND RECTUM, FOR THE DIFFERENT METHODS OF APPLYING RADIUM TO THE CERVIX

Method of Application of Radium	Cm. Lateral to Lower Capsule that 15 T. E. D. are Delivered	Cm. Lateral to Middle of Tandem that 7 T. E. D. are Delivered	Maximum Dose in T. E. D. Delivered to Bladder and Rectum
Tandem for 3,000 mg.-hrs.	1.0	2.0	5
Tandem plus bomb	1.3	2.1	6
Tandem plus plaque	1.3	2.1	7
Tandem plus needles	1.5	2.2	7
Tandem for 5,000 mg.-hrs.	1.5	2.5	8
Tandem plus colpostat	3.0	3.3	7

under consideration. However, in some instances it may be impossible to apply radium by any of the methods that have been discussed.

The charts presented here have been prepared for comparing the distribution of radiation from various methods of applying radium to the cervix. The criteria by which the efficiency of any method may be judged in this manner are based upon expressions of the amount of radiation reaching any given point. In each instance several factors are to be considered. The dose delivered to the primary lesion must be sufficient to control the disease in this region, but amounts of radiation that will cause a marked degree of necrosis and sloughing should be avoided. The dose delivered to the parametria is of importance for estimating the volume of tissue that receives a lethal dose. The amount of radiation reaching the bladder and rectal regions must also be noted for each method. A technic that will deliver a lethal dose to the greatest volume of tumor tissue without over-irradiating any particular region, will be the most suitable method for applying radium to the cervix.

The distribution of radiation for the various methods of applying radium has already been discussed in detail. For purposes of comparison, the points at which certain doses are delivered may be tabulated for the various technics of treatment. In considering the distribution of doses sufficient to cause necrosis and sloughing, the distance lateral to the middle of the lower capsule of the tandem that a minimum of 15 threshold erythemas is delivered will be noted. The volume of tissue that receives a lethal dose will be indicated by recording the distance lateral to the middle of the tandem that seven threshold erythemas are delivered. In each instance the maximum amount of radiation reaching the bladder and rectum will be estimated.

These data are given in Table I. It will be noted that the sequence of tabulation is different from the order in which the methods were discussed. If the column showing distances lateral to the lower capsule that 15 threshold erythema doses are delivered is considered first, it can be seen that the tandem for 3,000 mg.-hr. delivers this amount of radiation to a lesser volume of tissue than the other methods. Combining the bomb or plaque with the tandem increases this volume slightly. If the tandem is combined with needles, or used alone for 5,000 mg.-hr., 15 threshold erythema doses will be delivered to an even greater volume of tissue. The method shown for employing the colpostat delivers this dose at the greatest distance from the lower capsule. However, as was noted in the discussion of the diagram illustrating the colpostat, this dose is delivered lateral to the cervix into a volume that is occupied chiefly by the intravaginal applicator itself. There was no region that received more than 25 threshold erythema doses. Therefore, a technic in which radium is placed lateral to the intra-uterine tandem will deliver a lethal dose to a primary lesion of greater size than any of the other methods described, without delivering excessive amounts of radiation from any particular source.

In considering the column indicating the

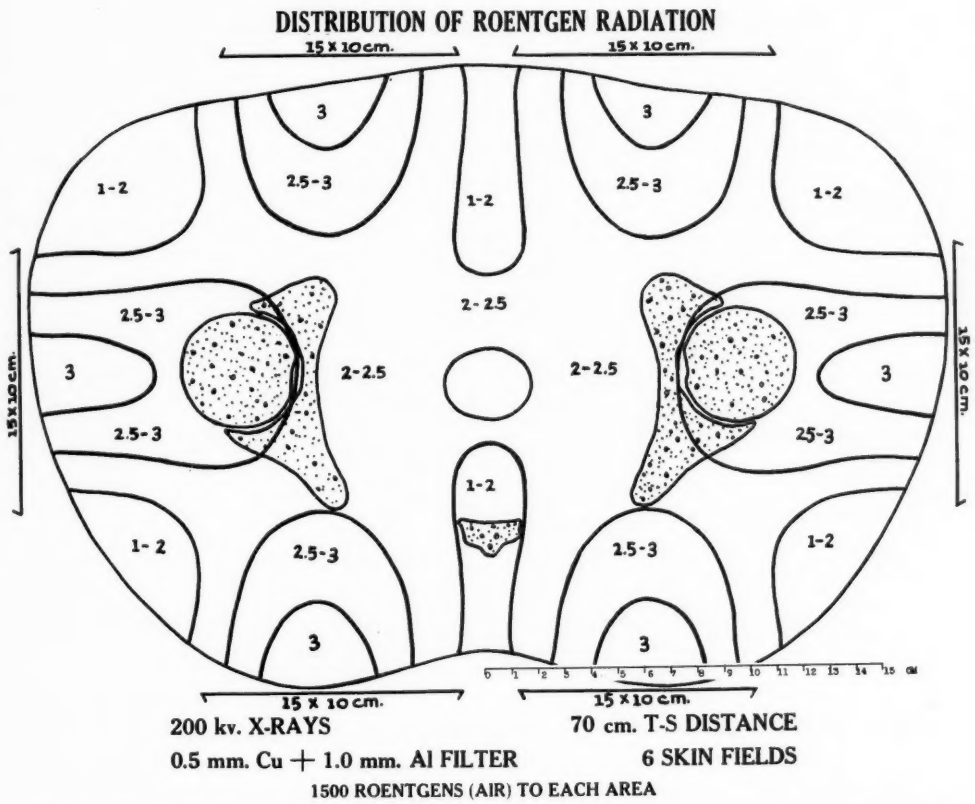

Fig. 8. The distribution of threshold erythema doses within the average female pelvis for the specified factors (1,500 roentgens to each area).

distances lateral to the middle of the tandem that a lethal dose (seven threshold erythemas) is delivered, it will be noted that the tandem for 3,000 mg.-hr. delivers this amount of radiation to a lesser volume of tissue than any of the other methods. The volume is increased slightly by combining the tandem with the bomb, plaque, or needles, and by delivering 5,000 mg.-hr. from the tandem alone. The greatest increase in the distance lateral to the tandem that seven threshold erythema doses are delivered, is obtained in the method employing the colpostat. The increase is of a degree that would have justified the use of the colpostat, whenever anatomical conditions permitted such an application, even when a minimum dose of 15 threshold erythemas was delivered to a greater volume of tissue. The tandem and colpostat could be used for lesser doses than have been illustrated, and still deliver a lethal dose to a greater volume of tissue than has been shown for the other methods.

Finally, the amount of radiation delivered to the bladder and rectum must be considered. The doses that these structures receive will show considerable variation in individual patients. An attempt has been made to estimate the maximum amount of radiation that would be delivered in any instance. However, only the portions of the bladder and rectum adjacent to the uterus would receive these doses. Due to the rapid fall in percentage depth doses for applications of radium that

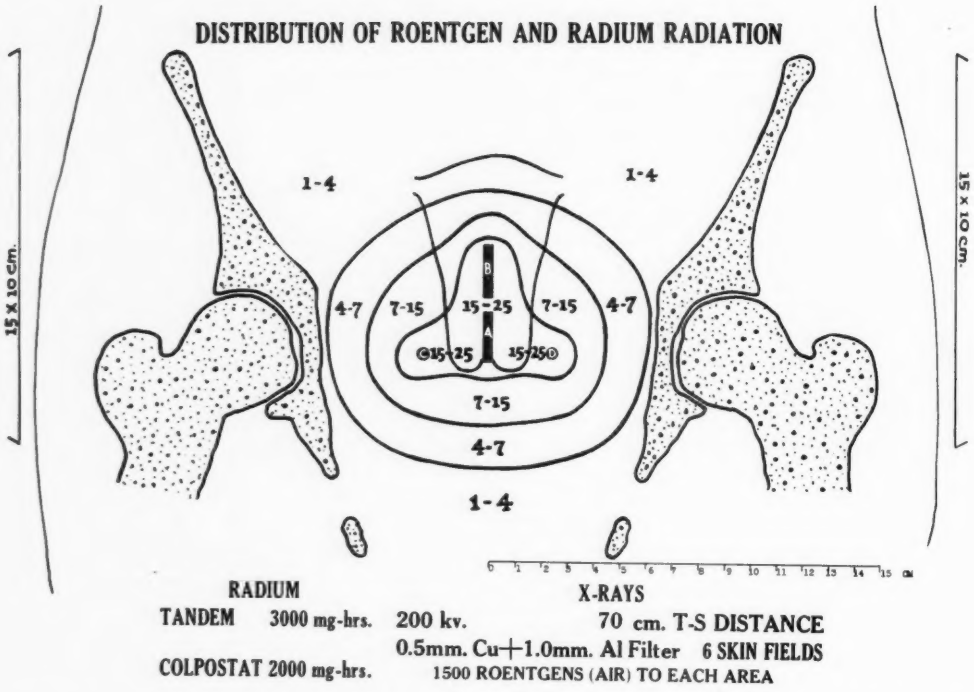

Fig. 9. The distribution of roentgen and radium radiation within the average female pelvis for the methods and doses specified.

have been shown, much smaller amounts of radiation would be delivered to the bulk of the bladder and rectum. From the table already referred to, it can be seen that a lesser dose is delivered to these structures by the tandem for 3,000 mg.-hr. than for any of the other methods. The greatest amount of radiation is delivered by the tandem for 5,000 milligram-hours. The dose these structures receive from the method employing the colpostat is about the same as is delivered by the technics that have been shown for the use of the plaque and needles.

From these comparisons it is evident that a technic employing methods for delivering radiation into the lateral vaginal fornices, in combination with an intrauterine tandem, is the most suitable for the treatment of cervix cancer. It has also been shown that, for doses within reasonable limits of tissue damage, it is impossible to deliver a lethal amount of radiation for a distance of more than three or four centimeters lateral to the tandem. For control of the disease beyond the zone of effect by radium applied to the cervix, some other means of treatment must be employed. External irradiation by roentgen rays is the method used most frequently for this purpose. Since the parametria are involved in most instances, the administration of roentgen radiation is just as important as the application of radium to the cervix. The amount of external irradiation that must be delivered for treating adequately the tumor in the parametrial regions, will usually produce some constitutional reaction in the patients receiving the dose, and an erythema of a rather marked degree in the irradiated skin fields. It is important, therefore, that the tissue damage at the site of the application of radium be limited to a degree that will not interfere with the administration of roentgen rays. The use of roentgen radiation in conjunction with

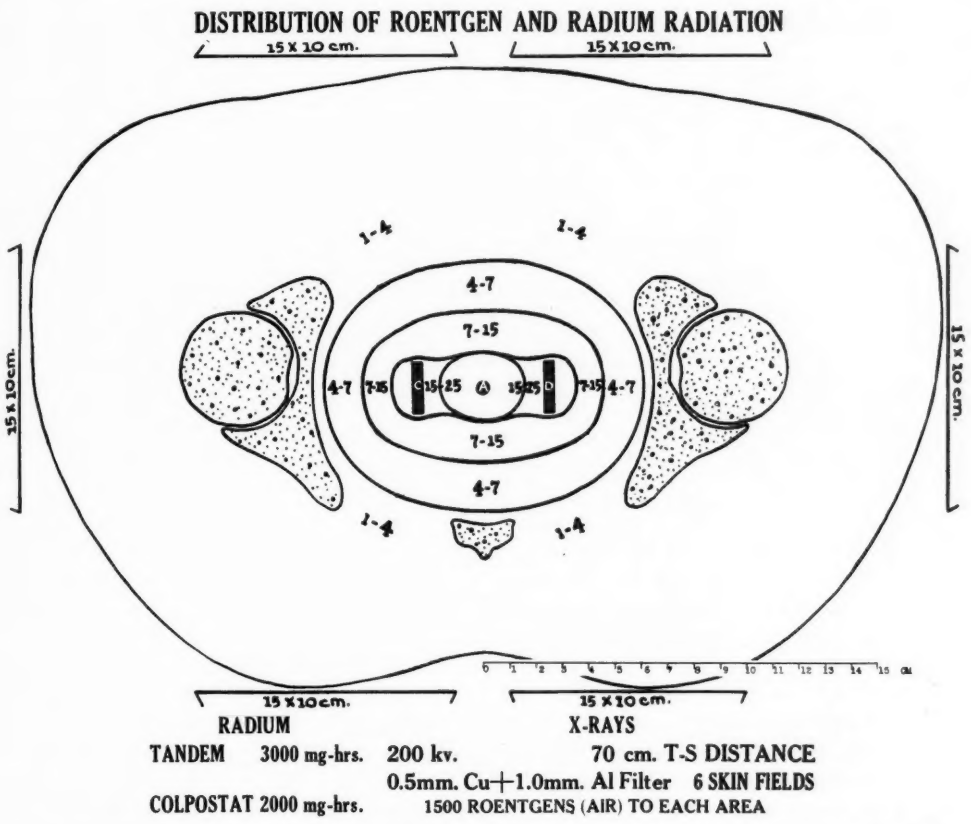

Fig. 10. The distribution of roentgen and radium radiation shown in a transverse section of the average female pelvis.

radium applied to the cervix delivers greater doses to points throughout the pelvis than could be obtained from either method alone. By this means the volume of tissue receiving a lethal dose will be increased, whatever the method of applying radium to the cervix. The degree of increase will depend upon the amount of roentgen radiation reaching the tumor. It has been predicted that advance in the treatment of cervix cancer will be through the improvement of the methods for delivering external irradiation.

For specified factors the distribution of roentgen radiation within the average female pelvis has already been shown in Figure 1. The size and location of the skin areas, and the manner in which the various beams were directed, have been described. Doses delivered to points throughout the pelvis were expressed in terms of percentages of the surface dose. If the amount of radiation delivered to each field is specified, the distribution of radiation can be shown in terms of threshold erythemas. Most patients will tolerate a dose of 1,500 roentgens (air) to each of six pelvic fields, if administered over a period of at least from 18 to 24 days. In Figure 8 is shown the distribution of threshold erythema doses for this amount of external irradiation, when other factors are the same as have been given.

In Figure 9 is shown the distribution of radiation for x-rays in conjunction with the tandem and colpostat. The doses from the

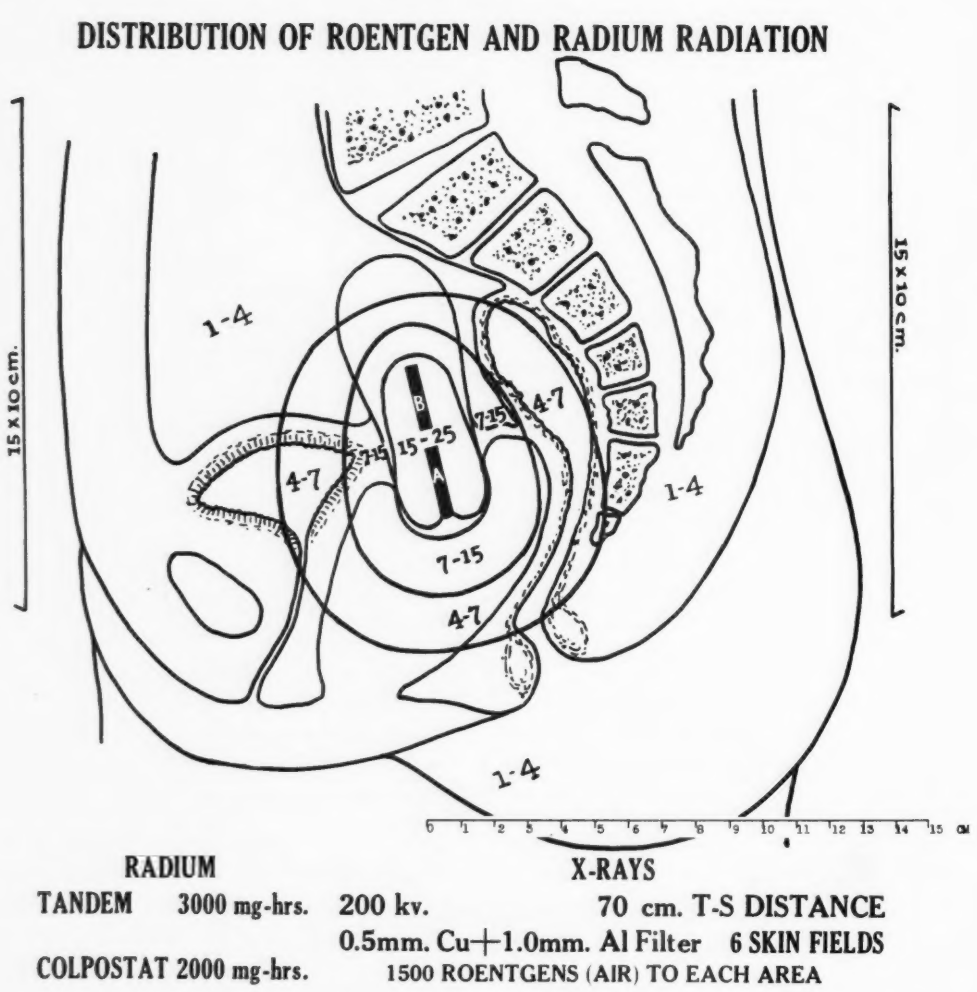

Fig. 11. The distribution of roentgen and radium radiation shown in a median sagittal section of the average female pelvis.

sources of radium radiation are the same as have been shown for this type of application. From the diagram it can be seen that a lethal tumor dose (seven threshold erythemas) is delivered into the parametrial regions for a distance of about 4.5 cm. from the middle of the tandem. Four threshold erythema doses, which would produce marked changes in the tumor, are delivered almost to the lateral pelvic walls. The remainder of the pelvis receives from one to four threshold erythemas.

The distribution of radiation in a transverse view of the pelvis is shown in Figure 10. Specified doses are delivered for a greater distance lateral to the tandem, than in the anterior or posterior direction. This is due to the sources of radium radiation that are located in the vaginal fornices, a fact which illustrates the advantage of such applicators as the colpostat for delivering a distribution of radiation suitable to the treatment of cervix cancer. The doses delivered to the bladder and rectum

are indicated in the median sagittal view of the pelvis, shown in Figure 11. Most of the bladder receives from four to seven threshold erythema doses. However, there is a portion near the uterus to which a maximum dose of about ten threshold erythemas might be delivered. The rectum receives about four to seven threshold erythema doses.

The doses that have been indicated for points throughout the pelvis probably represent the maximum amount of radiation that can be delivered safely to most patients. In many instances it may be necessary to employ lesser amounts than have been shown. For other doses, or patients presenting different anatomical conditions, these data are not directly applicable. They may, however, be used as a basis for approximating the amount of radiation delivered to any particular region.

SUMMARY AND CONCLUSIONS

The distribution of radiation throughout an average female pelvis has been studied for a variety of methods for applying radium to the cervix. A comparison can be made of the relative effectiveness of the various methods considered. For each plan, the distribution of radiation has been illustrated by showing differences of several threshold erythemas, which have been grouped according to greater or lesser amounts of radiation than the supposed lethal dose for cervix cancer. The reasons for employing this unit for expressing doses delivered to points throughout the pelvis have been given. It has been shown that a technic employing methods for delivering radiation into the lateral vaginal fornices, in combination with an intra-uterine tandem, delivers a distribution of radiation that is best suited to the treatment of cervix cancer. The colpostat can be used for this purpose, by means of which a lethal dose is delivered to a greater volume of tissue, without over-irradiating any region, or delivering excessive doses to the bladder or rectum.

It has been shown that, for doses within reasonable limits of tissue damage, it is impossible to deliver a lethal amount of radiation for a distance of more than three or four centimeters from the intra-uterine tandem. Roentgen treatment is the method most frequently used for delivering radiation to parametrial disease beyond the zone of effect by radium applied to the cervix. We have illustrated the addition of specified doses of roentgen rays to the radiation from an intra-uterine tandem in combination with a colpostat whereby the volume of tissue that receives a lethal dose is increased. Advance in the treatment of cervix cancer will be made by improving the methods for delivering external irradiation, rather than in employing different technics for applying radium to the primary lesion.

Due to the variation in the anatomical conditions presented by individual patients, no single plan is suitable for the treatment of all cases. In some instances it may be impossible to apply radium by any of the methods that have been considered. However, it is considered desirable to deliver radiation into the vaginal fornices, whenever anatomical conditions permit such an application. Despite the fact that the charts illustrate certain specified conditions, it will readily be seen that the data given for each technic can be applied to other cases, when the anatomical conditions and the dimensions of the uterus and pelvis, are known.

The author wishes to express his appreciation to Dr. Sherwood Moore, Dr. Otto Schwarz, and Dr. Q. U. Newell, of Washington University, and to Dr. W. P. Healy, of Memorial Hospital, New York, for their interest and advice during the course of this work. He also wishes particularly to acknowledge his indebtedness to Mrs. Edith Quimby, of Memorial Hospital, who supplied the data on which the isodose curves for radium are based, and offered many constructive suggestions. Without her co-operation, it would have been impossible to have written this paper.

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THE X-RAY ASPECTS OF PNEUMOCONIOSIS[1]

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THE early detection and correct classification of pneumoconiosis is still one of the difficult problems in diagnostic roentgenology. It may, therefore, be of interest to summarize recent observations concerning the diagnosis and differential diagnosis of the disease, and to discuss its classification from the point of view of the clinical radiologist.

Pneumoconiosis has been defined as the series of injurious changes, fibrotic and usually progressive in character, produced in the lungs by the inhalation of unusual quantities of certain dusts. While dust containing particles of silica is the chief offender, it is now known that certain silicates, coal dust, and other dusts also produce changes. Some workers believe that sericite, hydrous aluminum silicate, rather than silica, SiO_2, is the principal noxious agent, but agreement is far from complete on this point; Cummins (1) recently observed that "silicosis" may yet be found to be "silicatosis." The majority favor silica as the cause and believe that it produces specific changes in the cells of the lung either on account of its colloidal properties or by acting as a protoplasmic poison (16). In spite of modern preventive methods in industry, it is alleged that the incidence of pneumoconiosis is increasing. It is quite certain that the industrial production of fine silica powder, now an important constituent of many chemical compounds in daily use, is on the increase. Lanza and Vane (7) estimate that over half a million workers in the United States are exposed to the silica-dust hazard (and that the mortality from tuberculosis is appreciably affected by such).

TECHNIC OF ROENTGEN EXAMINATION

The diagnosis of pneumoconiosis is based on (1) the history, (2) the clinical findings, and (3) the roentgen findings. The weakest link in the chain is the clinical examination and the strongest the roentgen evidence. The diagnosis requires the intelligent correlation of all three types of data, and, since it constitutes the strongest link, the most thorough type of roentgen examination. This examination should include (*a*) a careful fluoroscopic examination, to aid in the detection of complicating emphysema, pleural adhesions, cavities, and right-sided cardiac enlargement, and (*b*) clear sharp teleroentgenograms made in $^1/_{20}$ of a second or less. The latter should consist of stereoscopic anterior and plain lateral films, as a minimum procedure; the importance of intensifying screens with good contact cannot be over-emphasized. Re-examination at the end of four weeks is frequently necessary to exclude the existence of complicating acute inflammatory processes which may exaggerate a mild fibrosis at the initial examination. In the average mild or early case, re-examination at intervals of one year for a three-year period is necessary to determine whether or not the changes are progressive in character. We would like to draw attention to the enormous sums now being spent both in compensation to workers disabled by pneumoconiosis and in protracted litigation. We believe that the time has come when an adequate type of roentgen examination should be instituted in all routine surveys of workers and applicants for work in daily occupations. The commonly seen "single postero-anterior film," often made with an inefficient and antiquated portable x-ray unit, seems like a very false type of economy when one considers both the health and the financial risk involved.

ROENTGEN DIAGNOSIS AND CLASSIFICATION

The roentgen appearance of the lungs in pneumoconiosis is so variable that a brief description of the findings, irrespective of the stage and type of the disease, is

[1] Read before the San Francisco County Medical Society, Sept. 17, 1935.

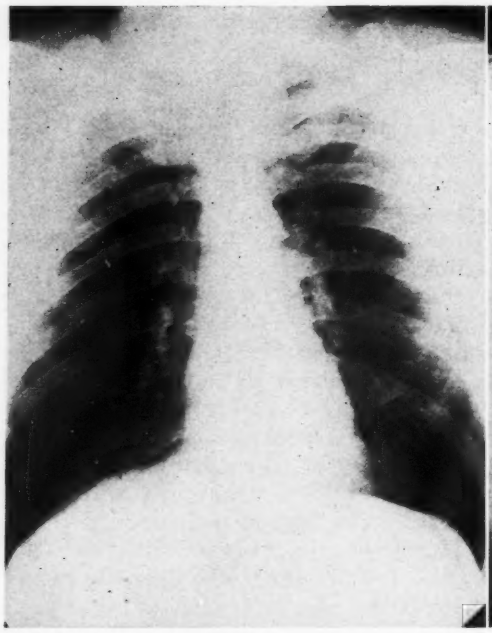

Fig. 1.

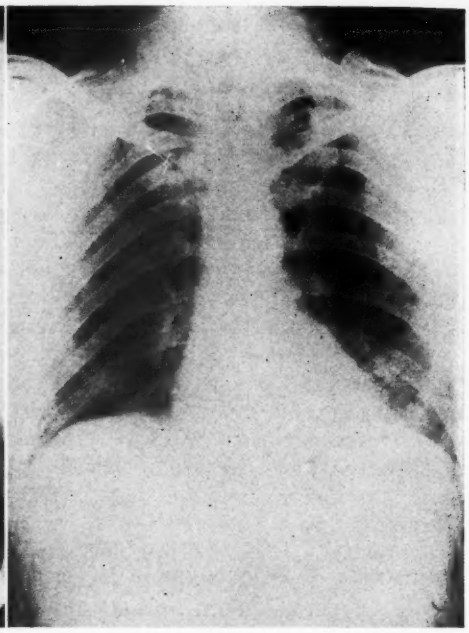

Fig. 2.

Fig. 1. Roentgenogram showing a normal chest. Normal adult thorax (male, aged 38 years), at *full inspiration*. Normal fibrovascular hilar and parenchymal (or pulmonary tree) markings. Normal diaphragmatic position and outline.

Fig. 2. Roentgenogram showing a normal chest. Normal adult thorax (same patient as in Figure 1, made on the same day), at *full expiration*. Note how the hilar markings are widened and the middle and lower pulmonary tree markings are accentuated. Elevated diaphragm. (Exposure technic and development identical with that used in Figure 1.)

impossible. This is quite natural, since the roentgenograms clearly reflect the morbid changes present, and these are highly variable. The text-book picture of "diffuse mottling, symmetrically distributed throughout both lung-fields, but usually sparing the apices" is observed frequently in large surveys of mine workers, but is far from being the most usual type seen in general radiologic practice in our experience.

Since the type and especially the stage of the disease influences the roentgen picture so strongly, it will be well to discuss the classification of pneumoconiosis before considering the roentgen diagnostic features in detail. From the roentgenologic point of view it is customary to classify the disease into three stages. Reichmann (5) considers this division useless and incorrect, since in his opinion no sharp limit can be drawn between the first and second stages; indeed, it may happen that the disease will pass directly from the first to the third stage without presenting any features of the second stage. Some confusion exists owing to the fact that some authors report as *stages* of the disease what other authors report as *types*. The fact of the matter seems to be that the types are so multitudinous that it is almost impossible to group them all into any brief pathologic or roentgenologic classification; however, an attempt at such is necessary for purposes of simplifying diagnosis and understanding the progress of the disease. Since most well established cases are fundamentally progressive in nature and fibrotic in type, the simple division into three stages, based on early, moderate, and advanced changes is popular and, indeed, still official with some authorities (*cf.* the reports of the International Silicosis Congress in Johannesburg). However, this

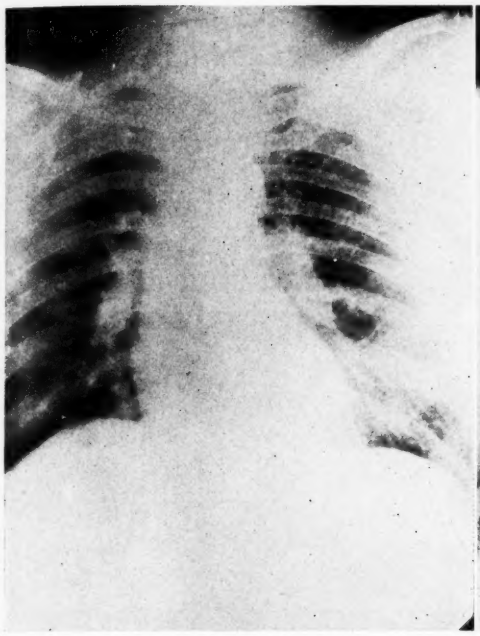

Fig. 3.

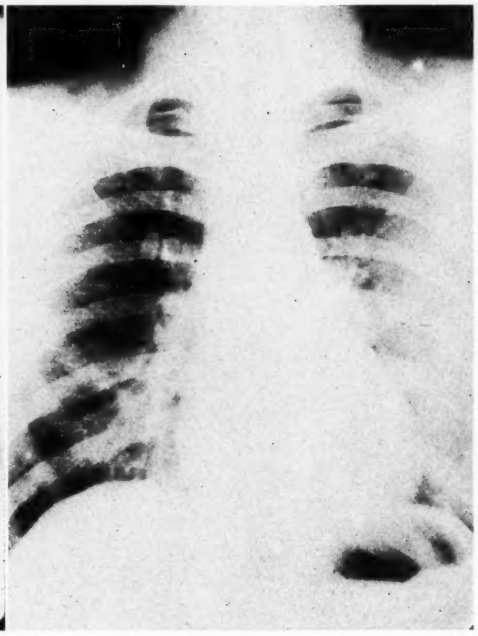

Fig. 4.

Fig. 3. Roentgenogram showing pneumoconiosis, incipient type. Hilar shadows wider and denser than normal; thickening of the perihilar pulmonary tree markings. Finnish miner, aged 46 years, with no pulmonary symptoms, had been doing hard rock mining for several years. (Roentgenograms made on account of cervical cellulitis following a neck wound.) Roentgen interpretation: probable mild pneumoconiosis.

Fig. 4. Roentgenogram showing pneumoconiosis, early interstitial type. Hilar shadows are slightly increased in width. There is a thickening of the smaller pulmonary tree markings in the middle two-thirds of both lungs; there is a hazy appearance of the middle third of the left lung. Austrian baker, aged 37 years, suffered with chronic parenchymatous nephritis and secondary anemia. He had a slight cough and nocturnal dyspnea. Roentgen interpretation: possibly miliary tuberculosis, early pneumoconiosis or passive congestion. Necropsy five months later showed extremely marked anthracosis, with some fine, patchy fibrosis, no parenchymal tubercles, but several tiny, healed, pleural tubercles. Also chronic nephritis, slight ventricular hypertrophy, and so forth.

does not clarify the variation in types seen, nor the fact that while many Stage I cases progress to nodular changes in Stage II, others remain interstitial in type throughout the course of the disease (diffuse fibrosis). Most authors describe Stage I as showing increased density and widening of the hilar shadows, with thickening of the perihilar linear markings; other authors, on the grounds that these changes are not typical of pneumoconiosis, describe Stage I as a fine mottling in the center of the lung-fields with perihilar thickening.

For purposes of classification, we shall outline what is generally understood by the Three Stage Classification; then we shall reproduce the pathologico-roentgenologic classification recommended by some well-known authorities; and, since this appears too complex for general use by the clinical radiologist, we shall outline a simple classification which, in our opinion, satisfactorily covers the problem.

In summarizing the roentgen appearance visible in the various stages or types, it is to be remembered that these changes usually are by no means pathognomonic; however, they *are* the changes visible in roentgenograms in the majority of cases of uncomplicated occupational pulmonary fibrosis.

(*A*) *The "Three Stage" Classification*

Stage I. Hilar shadows slightly wider and denser than normal; pulmonary tree

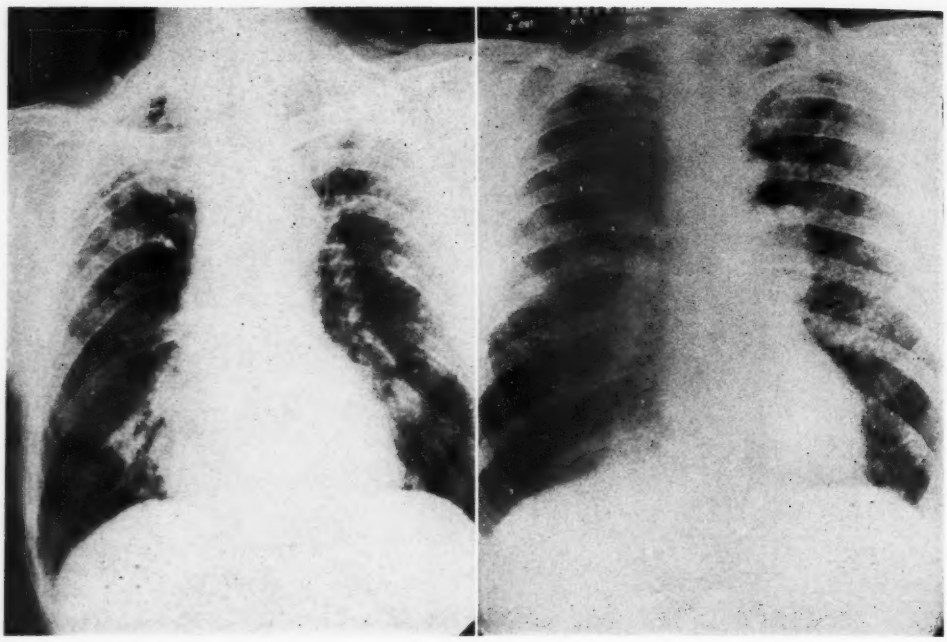

Fig. 5. Fig. 6.

Fig. 5. Roentgenogram showing pneumoconiosis, early nodular type. Right hilum widening; thickening of the smaller pulmonary tree markings throughout most of the lungs; thickening of the larger pulmonary tree markings at the right base mesially; slight nodulation.

American miner, aged 84 years, who had Osler-Vacquez disease and splenomegaly. He had been a stonecutter and miner for several years. Roentgen interpretation: irregular pulmonary fibrosis, possibly pneumoconiosis. Necropsy some months after this film was made showed fibrosis, especially of the left lower and right upper lobes, interpreted as mild pneumoconiosis. The patient had broken his hip and had developed bronchopneumonia.

Fig. 6. Roentgenogram showing pneumoconiosis, nodular type. Hilar shadows broadened and increased in density; thickening of the smaller pulmonary tree markings and soft nodulation throughout both lungs; moderate flattening of both diaphragms; confluent density at the right base mesially. American miner, aged 41 years, who had dyspnea for one year, and cough with weight loss for six months. Roentgen interpretation: pneumoconiosis, nodular type. Stage II.

markings slightly thicker than normal; occasional hazy appearance about the middle, or middle and lower thirds of the lungs.

Stage II. The above changes are more marked; slight diffuse nodular thickening of the pulmonary tree markings; slight or moderate limitation of diaphragmatic excursion.

Stage III. Diffuse thickening of the pulmonary tree markings, with or without diffuse scattering of small discrete nodules; limitation of diaphragmatic excursion; emphysema; occasional coalescence of areas of fibrosis or nodulation; enlargement of the right side of the heart; hilar shadows less prominent than usual; occasional cavitation.

(*B*) *The Detailed Pathologico-roentgenologic Classification of Pancoast and Pendergrass*[2]

(1) Peribronchial-perivascular-lymph node predominance { rapid / slow

(2) Early interstitial predominance (interferes with diaphragmatic movement) { with nodular appearance / without nodular appearance / rapid or slow

(3) Late or advanced interstitial predominance

(4) Nodular predominance { non-progressive / progressive

(5) Advanced diffuse or terminal fibrosis { conglomerate nodular interstitial type / massive fibrosis type

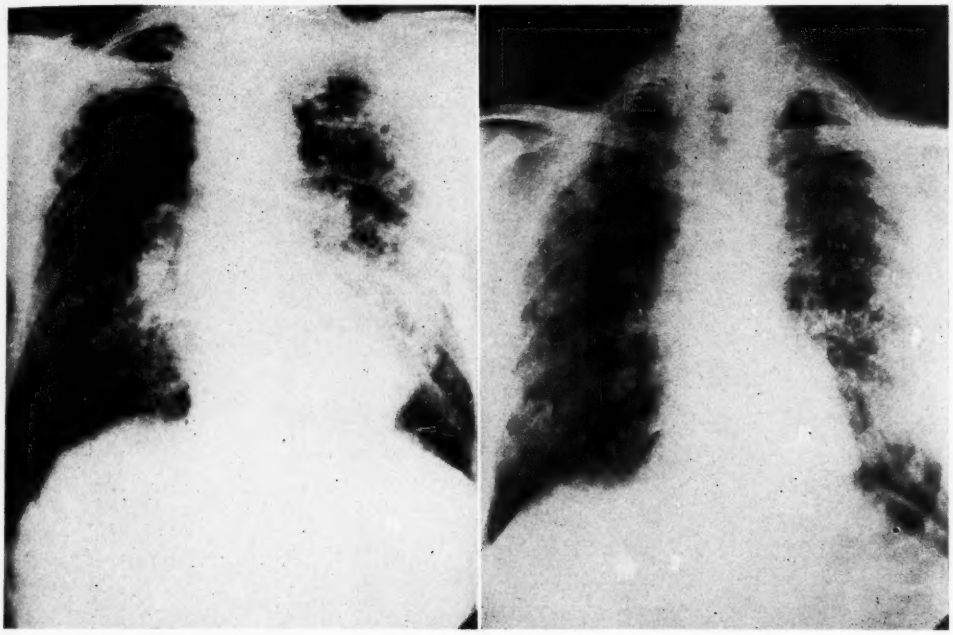

Fig. 7. Fig. 8.

Fig. 7. Roentgenogram showing pneumoconiosis, marked nodular type. Diffuse scattering of small soft nodules throughout both lung-fields with some coalescence of the nodules in the lower half of the left lung; possible cavitation in the left upper lobe; emphysema at both bases with some flattening of the left diaphragm.

American miner, elderly, with dyspnea. Roentgen interpretation: pneumoconiosis, nodular type, with possible associated tuberculosis (no clinical evidence of the latter).

Fig. 8. Roentgenogram showing pneumoconiosis, marked nodular type. Diffuse scattering of small, discrete, fairly firm nodules throughout both lung-fields. Slight flattening of the diaphragm at both bases.

Italian miner, aged 69 years, complained of weakness but no dyspnea. He had done all kinds of mining for many years. Roentgen interpretation: pneumoconiosis, marked. Necropsy eight months later revealed marked pneumoconiosis; patient also had carcinoma of the stomach, marked secondary anemia, etc.

(C) *A Simplified Roentgenologic Classification*

(1) Incipient type.
(2) Interstitial type.
(3) Nodular type.
(4) Advanced type.

1. *Incipient type.*—The hilar shadows are wider and denser than normal; the perihilar pulmonary tree markings are wider than normal.

2. *Interstitial type.*—In addition to the above findings, in early cases there is a faint haze in the middle or lower thirds of the lungs, and in well established cases there is diffuse thickening of the smaller pulmonary tree markings. Limitation of diaphragmatic excursion varies from slight to marked.

3. *Nodular type.*—The hilar shadows are wider and denser than normal; there is diffuse mottling throughout both lungs, especially in the middle and lower thirds, the shadows being small, dense, and discrete; the apices are usually free; there is moderate or marked limitation of diaphragmatic excursion.

4. *Advanced type.*—The hilar shadows appear to be less prominent than in the second and third types; there is diffuse thickening of the pulmonary tree markings with or without diffuse nodulation. There are small or large areas of density due to coalescence of fibrotic nodular lesions; there is emphysema, limitation of diaphragmatic excursion, and sometimes cavi-

[2] Since this classification is largely self-descriptive, we shall omit a detailed list of the roentgen findings for purposes of brevity.

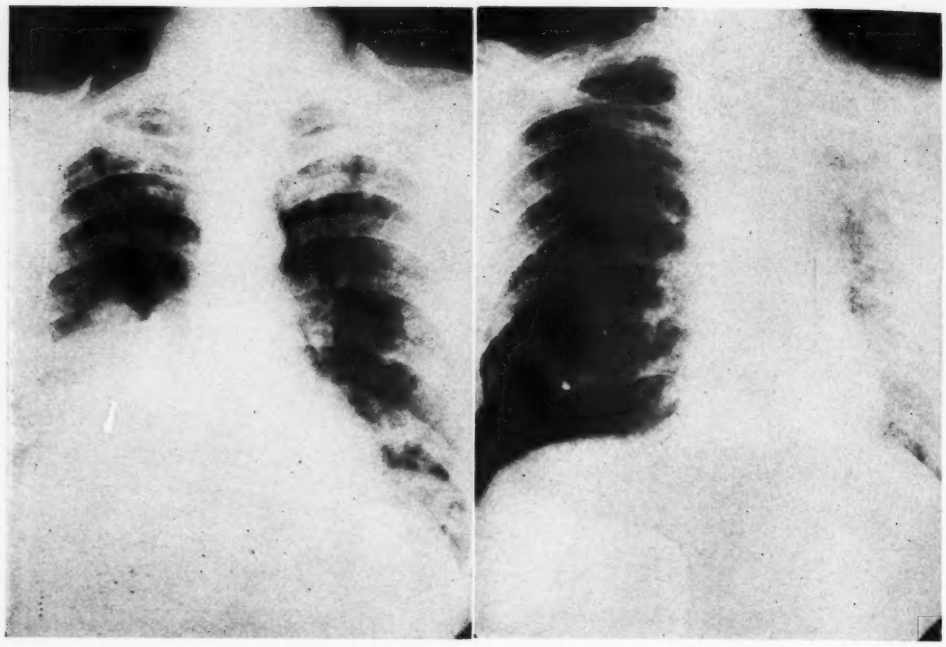

Fig. 9. Fig. 10.

Fig. 9. Roentgenogram showing pneumoconiosis, advanced type. Patchy thickening of the smaller pulmonary tree markings in several areas of both lungs; massive coalescence of areas of nodulation in the right lower lung-field and at the left base.

Italian farm laborer, aged 60 years, had pernicious anemia and subacute combined sclerosis. He had been a hard-rock miner for several years. Roentgen interpretation: partial consolidation of the right middle lobe either inflammatory or neoplastic; possible metastatic neoplasm in both lungs. Necropsy several months later revealed marked fibrosis of both lungs (pneumoconiosis, advanced), plus a small cavity in the right lung from which a few tubercle bacilli were recovered.

Fig. 10. Roentgenogram showing tuberculosis simulating pneumoconiosis. Diffuse mottling of small, discrete nodules throughout the right and left lungs, with some shrinkage of the left lung and pleural thickening around the left upper lobe.

Scottish hostler, aged 58 years, had a cough, thoracic pain, and dyspnea. He gave no history of mining. Sputum was positive for tubercle bacilli on several occasions. Roentgen examination two years previously showed left upper lobe pulmonary tuberculosis with cavitation. In view of this it is evident that the patient has recently developed disseminated miliary pulmonary tuberculosis. Death: no necropsy.

tation. The right side of the heart is often enlarged.

Any of these types may be slowly or rapidly progressive, and may be complicated by any of the lesions mentioned below. The disease is usually more or less progressive in persons who have been exposed over long periods of time, but it is well recognized that persons with exposures of short duration to moderate quantities of dust may show no changes at all, while persons exposed to unusually massive amounts of silica (for example, in the pulverized sand industries) may develop a rapidly fatal disease with little macroscopic fibrosis or nodulation. In cases of this type, no separate stages are detectable. In mild cases of ordinary silicosis, a stationary phase may develop after cessation of exposure. The roentgen appearance is rendered confusing by the development of an associated pulmonary tuberculosis in many cases, which may arise by fresh infection or by so-called reactivation of a clinically obsolete focus. The "typical" progress of the disease will then be altered according to the severity of the tuberculous lesion.

Jonsson (5), on the basis of studies of lateral roentgenograms of a large number of porcelain workers, believes that the pulmonary lesions in uncomplicated sili-

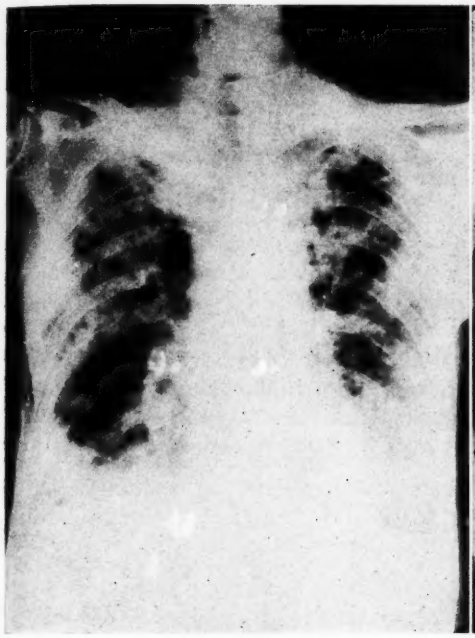

Fig. 11.

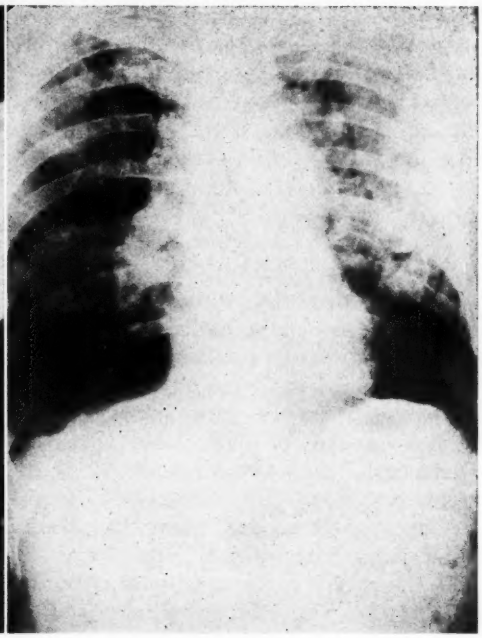

Fig. 12.

Fig. 11. Roentgenogram showing pulmonary syphilis simulating pneumoconiosis. Diffuse patchy thickening of the small pulmonary tree markings; coalescent areas of fibrosis at both bases.

American gardener, aged 69 years, complained of pain in the chest for four months, with occasional cough and hemoptysis. He had never done any mining. Sputum was negative for tubercle bacilli on six examinations; temperature, pulse and respiration were normal: Wassermann reaction was three plus. Clinical diagnosis: bronchiectasis, chronic pulmonary tuberculosis, arteriosclerosis. Roentgen interpretation as follows: diffuse pulmonary fibrosis, possibly tuberculous or syphilitic; bronchiectasis. The patient improved under anti-syphilitic therapy but later failed. Necropsy five months later showed diffuse pulmonary fibrosis, bronchiectasis, chronic adhesive pleurisy, but absolutely no evidence of tuberculosis, microscopic or otherwise, nor any evidence of mycotic infection, etc. Final diagnosis was *probable* interstitial syphilitic fibrosis of the lungs.

Fig. 12. Roentgenogram showing pulmonary syphilis simulating pneumoconiosis. Right hilum increased in width; extensive linear thickening of the pulmonary tree markings in the upper two-thirds of both lung-fields; extensive emphysema at both bases with irregularity of the right diaphragm.

Italian elevator operator, aged 57 years, complained of weakness, weight loss, and pains in the chest. Sputum was repeatedly negative for tubercle bacilli. Temperature, pulse, and respiration were normal. Blood Wassermann was two plus. Clinical diagnosis: chronic bronchitis and syphilis. Roentgen interpretation as follows: peculiar, bilateral, pulmonary fibrosis; probably old tuberculosis, left apex; possible syphilitic fibrosis. Patient died seven months later. Necropsy showed marked syphilitic aortitis; diffuse fibrosis of both lungs without any microscopic evidence of tuberculosis, mycosis or other granuloma. Stains for spirochetes unsuccessful. Dark field examination of sputum not done.

cosis are chiefly confined to the posterior portions of approximately the middle third of the lungs. He believes that the postero-inferior portion of the upper lobe and the postero-superior portion of the lower lobe show most of the changes. These areas correspond to the distribution of two bronchial branches, the dorso-lateral branch of the upper lobe bronchus and the first dorsal branch of the lower lobe bronchus. While such a well localized distribution may occur in Swedish porcelain workers, it does not appear to occur in general types of pneumoconiosis in our experience.

In connection with the diagnosis of emphysema, it is now believed that the position of the diaphragm and the apparent increase in translucency of the chest are not reliable roentgen signs. Flattening of the diaphragm and poor mobility is of some aid. Pancoast and Pendergrass (13) believe that the most reliable evidence is found in the lateral films. In emphysema, owing to hyper-aeration of certain portions

of the lungs, the anterior and posterior mediastinal air-shadows are widened; the space between the heart and sternum, and the retro-cardiac space will be greater than normal. We have not been impressed with the value of this evidence, and find the diagnosis of moderate emphysema quite difficult.

DIFFERENTIAL DIAGNOSIS

The detection of pneumoconiosis in its early stages demands familiarity with the *normal roentgen appearance* of the adult lung. We tend to forget that the normal hilar and pulmonary tree shadows are largely vascular in origin, and that the latter are subject to exaggeration or obliteration by over-lying pectoral shadows, respiratory and cardiac movements, and by incomplete inspiration (Figs. 1 and 2).

The normal hila are composite shadows made up of the bronchi, pulmonary vessels, lymph nodes, and connective tissue around the roots of the lungs. While highly variable, the Normal Chest Committee (10) have defined the normal standards as follows:

"The constituent trunk or vessel shadows should be distinguishable under normal exposures; the hilus should not be made up of any solid mass of homogeneous shadow. The right hilum extends from the top of the right main bronchus to the point of division of the right lower lobe bronchus. The left hilum extends from the upper portion of the pulmonary artery shadow to the point of division of the left lower lobe bronchus."

Sampson (15) writes:

"In considering the very slight alteration in the pulmonary field which insignificant anatomical changes produce, one must bear in mind certain manifestations of the normal chest; the movement of the pulmonary markings at the left base due to the heart beat may well be mistaken for the cloudiness expected in early silicosis. Similarly, the shadow of the margin of the pectoralis muscle is not unlike that shadow seen in cases of beginning fibrosis. However, the shadow of the muscle is situated more peripherally and continues beyond the pulmonary field, while the intrapulmonary haziness of silicosis is usually more centrally located. Also, in the case of the pectoralis muscle the lung markings are visible through the shadow of the muscle, whereas the enveloping intra-pulmonary infiltration produces cloudiness which tends to obscure the vascular ramifications. In general, if the cloudiness, which has not yet assumed the nodular appearance, is confined to the region of the pectoralis muscle or to the left base, and if no alteration of the pulmonary pattern is seen above this level, we may not be justified in believing we are dealing with a pathologic process. After the stage of nodulation has been reached it is not difficult to recognize characteristic mottling."

The following diseases must be taken into consideration in the differential diagnosis of pneumoconiosis in its various types:

Incipient Type.—The incipient type may be confused with:

Passive congestion of the lungs (cardiac);
Acute respiratory tract infections;
Asthma.

Interstitial Type.—The interstitial type may be confused with:

Passive congestion of the lungs (cardiac);
Acute and chronic respiratory infections (especially bronchitis and bronchosinusitis);
Polycythemia;
Lymphoblastoma (infiltrative Hodgkin's);
Mycoses;
Pulmonary syphilis.

Nodular Type.—The nodular type may be confused with:

Miliary tuberculosis;
Metastatic malignancies (miliary carcinosis);
Periarteritis nodosa.

Advanced Type.—The advanced type may be confused with:

Chronic pulmonary tuberculosis;
Pulmonary tumors;
Pulmonary syphilis.

From the roentgenograms alone it is often quite impossible to differentiate between some of the above disorders and pneumoconiosis. While the following points will be found of assistance in many cases, unquestionably the most valuable

single factor is a history[3] of exposure to dust.

In *passive congestion* of the lungs, the heart frequently will be enlarged to the left, there may be some fluid in the bases of the pleural cavities, and the perihilar shadows will be very broad in proportion to the peripheral linear shadows. Reexamination after compensation has been established will disclose disappearance of many of the vascular markings. The *acute respiratory* infections will be differentiated by the marked symptoms and by serial examination. In *asthma*, the hilar markings, while broadened, are not so dense and homogeneous as in early pneumoconiosis.

There are no really satisfactory differential features between early interstitial pneumoconiosis and some of the *chronic respiratory infections*. Serial examination and knowledge of the patient's occupation are essential. The same applies to polycythemia, metastatic infiltrating malignancy, and mycotic infections. Infiltrations of leukemic and lymphoblastomatous origin will clear up rapidly under moderate doses of radiation therapy.

The nodular type of pneumoconiosis may simulate *miliary tuberculosis*. In the latter, the mottling is usually softer, more hazy, and more uniformly distributed than in pneumoconiosis. Fluoroscopically, one will be aware of the sick condition of the tuberculous patient and the relative lack of symptoms of the average pneumoconiotic; in addition, diaphragmatic limitation is more apt to be present in the latter. Usually, miliary carcinosis is rapidly fatal. Periarteritis nodosa, which is rarely encountered, may be differentiated by the absence of an appropriate history and by other points, according to v. Conta (17).

[3] This history is frequently difficult to elicit. Elderly males often will give their occupation as janitor or elevator operator; when asked if any other one was followed, they will often say, "No." One must ask the specific questions: "Have you ever done any mining or worked in dusty occupations before you took up your present work? For how many years? What exact type of work was done?" etc.

The advanced type of pneumoconiosis frequently resembles *chronic pulmonary tuberculosis*, and of course is often complicated by that disease. However, a number of cases uncomplicated by tuberculosis are encountered, and in addition, many bizarre forms are seen. Chronic tuberculosis usually involves the upper rather than the lower two-thirds of the lungs; the lesions tend to show calcification and pleural changes are more marked. The hila tend to be dislocated upward rather than laterally, and the trachea to be displaced to one side. Healed miliary tuberculosis has been confused with pneumoconiosis; usually the spots are sharper, denser, and more regularly distributed than in the latter disease, and there is much less fibrosis. *Pulmonary tumors* rarely simulate pneumoconiosis, but the converse occurs not infrequently. Large coalescent areas of fibrosis or nodulation may perfectly mimic single or multiple metastatic tumors. Differentiation may be made by the detection of a primary, by evidence of growth on serial examination, by the presence of appropriate symptoms, and the lack of an occupational history. Pulmonary syphilis is such a debatable subject that we shall not consume space here with a discussion of its particular features; suffice it to say that cases clinically diagnosed as chronic interstitial pulmonary fibrosis, in persons with clinical and serologic signs of syphilis and without evidence of tuberculous or mycotic infection and with no history of exposure to dust, have been reported. The roentgen findings may be indistinguishable from those of the interstitial type of pneumoconiosis.

COMPLICATIONS

Most cases of pneumoconiosis develop insidiously and are chronic. Indeed, many cases show a long latent period between exposure and the development of demonstrable fibrosis. The most common complications are emphysema, limitation of diaphragmatic excursion, and pleural thickening. Severe cases develop bronchiectasis and even cavities (so-called black phthisis,

TABLE I.—ROENTGEN FINDINGS IN PNEUMOCONIOSIS

(UNCOMPLICATED OR SIMPLE PNEUMOCONIOSIS)

1. Incipient Type
   Hilar shadows wider and denser than normal; perihilar pulmonary tree markings wider than normal.
2. Interstitial Type
   Hilar shadows wider and denser than normal; slight or moderate diffuse thickening of the pulmonary tree markings, associated with faint haze in middle or lower thirds of the lungs in early cases; extensive thickening in well established cases;
   Limitation of diaphragmatic excursion (varying from slight to marked).
3. Nodular Type
   Hilar shadows wider and denser than normal; diffuse scattering of small, dense, discrete nodules throughout both lungs, especially in the middle thirds; apices usually free;
   Limitation of diaphragmatic excursion.
4. Advanced Type
   Hilar shadows less prominent than usual; diffuse thickening of the pulmonary tree markings, and/or diffuse nodulations; small or large areas of density due to coalescence of fibrotic or nodular lesions;
   Emphysema;
   Limitation of diaphragmatic excursion;
   Occasional cavitation;
   Enlargement of the right side of the heart.

TABLE II.—LESIONS SIMULATING PNEUMOCONIOSIS

(IN THE ROENTGENOGRAMS)

1. Incipient Type
   Passive congestion of the lungs (cardiac).
   Acute respiratory tract infections.
   Asthma.
2. Interstitial Type
   Passive congestion of the lungs (cardiac).
   Acute and chronic respiratory infections (especially bronchitis and bronchosinusitis).
   Polycythemia.
   Metastatic malignancies, infiltrative type.
   Mycoses.
   Lymphoblastoma (infiltrative Hodgkin's).
   Pulmonary syphilis.
3. Nodular Type
   Miliary tuberculosis.
   Metastatic malignancies (miliary carcinosis).
   Periarteritis nodosa.
4. Advanced Type
   Chronic pulmonary tuberculosis.
   Pulmonary tumors.
   Pulmonary syphilis.

TABLE III.—COMPLICATIONS OF PNEUMOCONIOSIS

(VISIBLE IN ROENTGENOGRAMS)

Emphysema.
Limitation of diaphragmatic excursion.
Pleural thickening and effusion.
Pneumonia.
Bronchiectasis and cavitation.
Cardiac enlargement (right side).
Cardiac failure.
Spontaneous pneumothorax.
Tuberculosis.
Chronic indurative pneumonia.
Bronchiogenic carcinoma.

the cavities being in the middle or lower lobes and non-tuberculous in nature). Spontaneous pneumothorax has been reported in a fair percentage of cases. Right-sided cardiac enlargement is not uncommon and cardiac failure supervenes in many advanced cases. Chronic indurative pneumonia with small or large areas of atelectasis has been reported. Bronchiogenic carcinoma is a rare complication. It is noteworthy that among many hundreds of cases, Pancoast and Pendergrass saw only three proven cases of primary lung cancer. They do not believe pneumoconiosis is a predisposing cause of bronchiogenic carcinoma.

Tuberculosis is the most serious complication and occurs in a variable percentage of cases, depending in part on the type of work involved. In a survey of 800 porcelain workers, Flemming-Moller (3) found a remarkably low incidence (1.7 per cent). On the other hand, in certain mining industries, the incidence of tuberculosis has been found to be over 70 per cent. Some pathologists regard all cases of pneumoconiosis as being complicated by low-grade chronic pulmonary infection, and most cases as being complicated by low-grade or moderate tuberculosis. Agreement is far from complete on this important question. Riddell (14) has recently observed that "clinically, if not pathologically, forms of silicosis occur in which it is impossible by clinical means to demonstrate an infectious element (*i.e.*, simple silicosis)." On the other hand, it is well to note Gardner's opinion (4) that "silicosis differs from most other forms of pneumoconiosis in that it specifically predisposes to infection with the tubercle bacillus; at least 75 per cent of patients with silicosis die of tuberculosis, which may make its appearance at any stage of the disease. Silico-tuberculosis is sometimes rapidly fatal, sometimes very chronic."

TABLE IV.—DIFFERENTIAL ROENTGEN DIAGNOSIS BETWEEN COMMON TYPES OF PNEUMOCONIOSIS AND TUBERCULOSIS

Pneumoconiosis	*Tuberculosis*
(*A*) *Nodular Type*	(*A*) *Miliary Type*
Soft or dense discrete "spots," *varying* in size, *irregularly* scattered throughout both lungs, usually more marked *centrally*, apices usually free, emphysema occasionally marked, pleural involvement slight, diaphragm movement limited	Soft, fuzzy "spots," small and *uniform* in size, *evenly* scattered throughout both lungs, as marked peripherally as elsewhere, *apices* involved, emphysema rare, pleural involvement common, diaphragm movement often normal
(*B*) *Advanced Fibrotic Type*	(*B*) *Chronic Fibroid Type*
Lesions often in *lower* two-thirds of lungs, with irregular emphysema, trachea often displaced *backwards*, hila often displaced *laterally*, cavitation and calcification rare, pleural involvement occasional, diaphragm excursion *limited*	Lesions often in *upper* two-thirds of lungs, with basal emphysema, trachea often displaced *laterally*, hila often displaced *upwards*, *cavitation* and *calcification* common, *pleural involvement* frequent, diaphragm excursion moderately limited

(Combinations of pneumoconiosis and tuberculosis, including silico-tuberculosis, may show predominant tuberculous changes.)

A very acute type of silicosis occurs among the workers in certain abrasive soap, scrubbing powder, glass, and vitreous paint industries, especially among packers of siliceous scouring powders (6). The roentgen findings in these cases consist of a faint, hazy nodulation, but with early limitation of diaphragmatic excursion. The disease may be so rapidly fatal that no second or third stage is manifested; the patients virtually die with a sub-acute interstitial pneumonia.

In asbestosis, the roentgenograms show a fine, diffuse pulmonary fibrosis, often commencing at the bases and spreading upward; the hilar markings are heavy and there is restriction of diaphragmatic movement (18). While isolated asbestosis bodies may be found in the sputum, they do not necessarily have clinical significance (Ellman, 2).

For several years it was believed that soft-coal handlers did not develop true pulmonary fibrosis, but merely densely pigmented lungs (anthracosis). However, it is now believed that some cases of anthracosis are associated with fine pulmonary fibrosis—benign anthracosis, in contradistinction to silico-anthracosis, which predisposes to tuberculosis (13). Coal miners illustrate very well the length of time usually required to produce marked fibrotic changes. This, of course, indicates that there is a low concentration of silica in the dust in question.

X-RAY TESTS OF FUNCTIONAL DISABILITY OF THE LUNGS

The clinically significant factors in pulmonary pneumoconiosis usually are the amount of functional disability of the lungs and the presence of complicating tuberculosis. In addition to the usual diagnostic roentgen examination, McCann *et al.* (8) studied many cases by area measurements of the pulmonary fields during maximum inspiration and expiration, and made records of the position of the ribs and the diaphragm. The results of these combined measurements indicated that in general the degree of disability parallels the degree of fibrosis present. However, many exceptions to this were found which emphasized the fact that one cannot accurately judge the degree of pulmonary disability by the roentgenograms alone.

X-RAY EXAMINATIONS OF SAMPLES OF DUST-CONTAINING AIR

We have recently seen reports on the use of x-rays to determine the concentration of silica in samples of air (Clark and Reynolds, University of Illinois, speaking at the 1935 American Chemical Society meeting in San Francisco). Since all workers believe that only silica particles of very small size are involved in the production of pneumoconiosis, and since some authors have suggested that there may actually be a critical size of particle involved, varying from 6 to 10 micra, it does not appear probable at first glance that this type of examination will be of great assistance. The particles must be small enough to float into the alveoli and be engulfed by endothelial cells . . . most being probably less than 6 micra in size.

SUMMARY

The extent, type, and location of the lesions of pneumoconiosis are always best demonstrated by roentgen examination, that is, by fluoroscopic study and stereoscopic postero-anterior and lateral roentgenograms.

A classification of pneumoconiosis into four main types, based on the extent and the type of the lesions present, is a simplification of existing pathologico-roentgenologic classifications, and is more accurate than the still generally used three-stage classification.

The roentgen findings only occasionally are pathognomonic of pneumoconiosis; however, linked with a clear history of exposure to silica-containing dust, they constitute the most valuable factor in diagnosis.

The roentgen findings frequently do not parallel the subjective clinical findings; usually they are more marked than the latter, but in the rapid interstitial type of silicosis, they may be much less marked than one would expect from the symptoms.

The roentgen examination is useful in deciding whether or not pneumoconiosis is complicated by pulmonary tuberculosis. It should be used in surveying applicants for employment in dusty industries (persons showing evidence of bronchosinusitis, asthma, pulmonary tuberculosis, and similar lesions being obviously undesirable for subjection to this potential health hazard).

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THE TREATMENT OF CARCINOMA OF THE BREAST BY EXTIRPATION OF THE TUMOR AND ROENTGEN IRRADIATION

(PRELIMINARY RESULTS)

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HIRSCH (1), of the Jewish Hospital of Berlin, reported, in 1927, on the results of tumor extirpation followed by radium treatment in cases of carcinoma of the breast. Of 22 cases, 21 were living, clinically well, and symptom-free after three years, 17 (77.7 per cent) after five years, and about the same number from six to thirteen years. That these outstanding results, in spite of the fact that they were confirmed by Halberstaedter (2), produced no noteworthy change in the methods of treating breast cancer is evidence of the difficulty with which a well established method of treatment may be changed. One of the contributory factors may well be the fact that radium therapy at that time was more exclusively confined to a few institutions than it is at present.

Our cases were treated exclusively by roentgen rays. Roentgen therapy has an advantage over radium therapy in that it may be almost universally carried out, and that usually during treatment the hospitalization of the patient is not necessary.

The greater portion of our 26 cases were operated on by Dozent Dr. W. Goldschmidt, Primararzt of the Surgical Division of the Hospital of the Isrealitischen Kultusgemeinde, and a former assistant in the Surgical Clinic of Eiselberg in Vienna. Goldschmidt deserves much credit for following out this method for the past ten years, and in view of the results he has obtained by it, even in those cases in which a radical operation seemed to be the method of choice, he has more and more often advised against the radical method of treatment (3).

Without going into greater detail let it be mentioned that, in those cases in which a tumor could be palpated in the breast and in which the axilla seemed clinically free of metastasis, only the tumor in the breast was removed. Also, the same procedure was followed in those cases in which only small axillary nodes could be palpated and when they did not seem to exceed the size of a pea. If a larger axillary tumor could be palpated, this together with the tumor in the breast was extirpated through a single incision. The basic idea in this procedure was to extirpate surgically all palpable disease and to take care of the microscopic phases by radiotherapy.

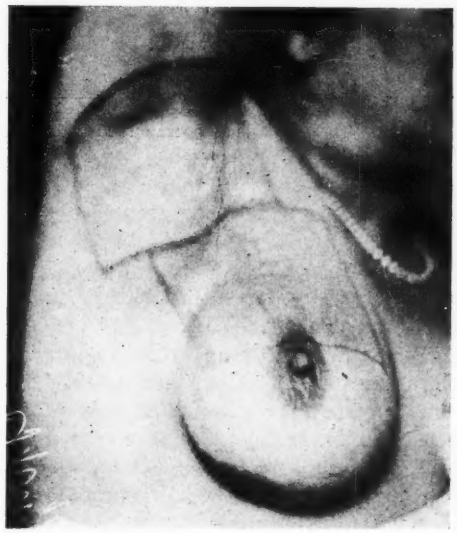

Fig. 1. The fields of irradiation.

When we started treatment about ten years ago, cases in which the tumor alone had been extirpated were treated in just the same way as those in which a radical operation had been performed. We have

Fig. 2. The right side operated on radically, the left side conservatively.

described the technic of treatment elsewhere (4). Our practice was to repeat several series of treatments in the course of a year, the total dose varying between 1,000 and 2,500 r. We came to the conclusion that doses of this magnitude, averaging about 2,000 r, which usually prevented recurrence after radical operation, were insufficient to prevent recurrence if only the tumor had been extirpated. In a group of 11 cases which received total doses of from 1,000 to 2,500 r, recurrences took place in nine instances; these recurrences took place with these doses even in those cases which were given a single series. The time of recurrence is also of great interest; in approximately 80 per cent of the cases it took place within the first year, and in two cases, one and one-half years and two years after operation, respectively. Recurrence, which was most common in the operative scar or in its immediate vicinity, may be classified in two sub-groups. The larger of these, of six patients, later had distant metastases. After local recurrence, metastasis took place in some cases after a few months, and in others after from one to three years. In most of these cases metastasis took place in the skeleton, and in others in the lungs or brain. In one case the recurrence was removed operatively.

The second sub-group of three cases later became free of evidence of disease.

Fig. 3. Patient had conservative operation in 1927, then post-operative radiation. She has been symptom-free since.

Of two cases, the recurrence was treated by local removal in one and by radical operation in the other. Both types of operation followed intensive roentgen therapy.

From this sketchy outline of results we see that local recurrence definitely makes the prognosis worse, because in two-thirds of these cases distant metastasis takes place. Only a few of these cases could be salvaged, and in two the breast was preserved. The fact that recurrence did not follow excision may well be explained by the admission that a much higher dose was given than in the first course of post-operative treatment.

Even more outstanding is the effect of even greater doses if we keep in mind the results obtained by the administration of doses between 3,000 and 6,000 r. In a group of 12 cases treated in this way recurrence took place only once, while in the other group of 11 cases which were treated with lower doses it took place in about 80 per cent.

A comparison between the two groups is very instructive from another point of view. Of the group of 11 cases which were treated with doses of from 1,000 to 2,500 r, distant metastasis took place in

six instances. Of the group of 12 cases which were treated with doses of from 3,000 to 6,000 r, distant metastasis occurred only once. This difference is explainable if we keep in mind the fact that in the first group distant metastasis took place before local recurrence, a situation which was prevented by heavier radiation in the second group. Therefore, we have a different set of conditions in our case from those in which radical operation has been done. Whereas, in the cases in which radical operation has been carried out, distant metastasis occurs without local recurrence, in those cases in which only local excision of the tumor has been performed, distant metastasis takes place usually after local recurrence. This course of events seems to justify the conception that in the extirpated cases the involvement of the blood stream by the recurrence leads to distant metastases, while in the cases radically operated on they take place as the result of the operative procedure itself. Regarded from this point of view it seems as if simple extirpation of the tumor is to be preferred to radical operation, because not only does this procedure leave the breast intact, but also because the normal movements of the arm are preserved by not entering the axilla. An outstanding advantage of this procedure seems to be that following extirpation it is possible to prevent distant metastasis to a far greater extent than after radical operation.

The success which we have had in substituting simple removal of the tumor for radical operation seems largely to depend on the effect of post-operative radiation. On it the value of the conservative operation stands or falls.

Under these conditions the technic of roentgen irradiation is of special importance.

From a radiotherapeutic point of view, the fact that recurrence (as has been mentioned) usually takes place in the operative scar or its immediate vicinity is of essential importance. For this reason we have in only the exceptional case, in which the tumor was below the nipple, treated the whole breast; in most cases the tumor is above the nipple, and for this reason in most cases we have treated the breast from the nipple to the anterior axillary line (Fig. 1). This field receives, in from 8 to 14 days following operation, in 12 consecutive treatments each of about 300 r, a total dose of 3,600 r at 40 cm. distance, 0.5 mm. zinc filter, 170 kv. Immediately afterward (or in those cases in which a severe reaction has occurred after an interval of from 8 to 14 days) treatment of the axilla is carried out in exactly the same way. Treatment of the supraclavicular space to which on more or less theoretical grounds great importance has been assigned we abandoned several years ago both in the radical and the conservative group. In our 26 cases in which there was no supraclavicular node present before operation, in not a single case did metastasis take place in spite of the omission of treatment of the supraclavicular space.

Figures 2 and 3 illustrate the cosmetic results obtainable by the extirpation of the tumor followed by post-operative roentgen therapy in cases of carcinoma of the breast.

In summary, we might state that a simple, safe method of irradiation has been found to be efficacious in preventing local recurrence in 80 per cent of the cases and distant metastasis during a minimal period of observation of one and one-half years. The oldest case under consideration is of nine years' duration.

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EVENTRATION AND HERNIA OF THE DIAPHRAGM AS AN INCIDENTAL FINDING

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CONSIDERABLE advance has been made during the last two decades in our knowledge of diaphragmatic lesions, and one of these, diaphragmatic hernia, is of especial interest to the internist, surgeon, and radiologist because in the majority of cases it is discovered by x-ray examination as an accidental finding during the course of a routine study. There is no single procedure which throws more sudden light on a vague or obscure clinical picture than the finding of a hernia through the diaphragm. Symptoms which are present vary widely; at times, they may be chiefly respiratory, cardiac, or gastro-intestinal, but at other times eventration or actual hernia is discovered in a person who has no complaint whatever. It is perfectly natural to suppose that the same general proportion of cases existed in the days before the x-ray was a recognized diagnostic method, but only a very few were reported in the earlier writings. The important point still remains that in the vast majority of cases the condition is not even suspected from the clinical point of view. Examinations were usually made for some other supposed condition which did not exist or during the course of routine study.

It is most important to know the position of the diaphragm in relation to the thoracic and abdominal organs and its motility. In the average person this offers no difficulty, but sometimes, due to overlapping of the diaphragmatic and viceral shadows, it is not definitely recognized on the radiographic film, and the motility is difficult to demonstrate fluoroscopically. The test of introducing gas into the stomach, either by means of a tube or effervescing powders, will not always settle the question of its relation to the diaphragm. This, however, is of considerable value since gas in the stomach will often demonstrate the overlying diaphragm with greater clarity, or show an increased degree of contrast in the herniated portion of the stomach above the level of the diaphragm. We wish to point out with especial emphasis the importance of gentle manipulation in several positions, watching the effect of the diaphragmatic motility on forced respiration and viewing the relation of diaphragm and abdominal viscera in various postures. By tilting the patient back in the Trendelenburg position to view the partially barium-filled stomach, a small hernia will often be detected projecting through the esophageal orifice which may not be recognized by any other procedure. It is always advisable to do the general fluoroscopy first in various postures before partially filling the stomach with gas, and to use the opaque meal last. It must, however, be borne in mind that there are hernias which do not contain the stomach and in these the difficulty of recognition is somewhat increased.

In Hedblom's report of 343 cases, 94 involved the stomach alone; 101, stomach and bowel; 86, bowel alone, and 62 were not classified. Some authors have attempted from statistical study to classify and explain the development of these hernias, but we believe it best to regard the diaphragm in the same manner as other muscular sheaths of the body. Thus, an individual may have a congenital weakness of the inguinal ring, but never suffer a true hernia; however, such a patient might be regarded as potentially liable to herniation. In a similar manner, it has been shown that there may be this potential weakness or unduly large opening at the esophageal orifice or about the crura, or there may be thinner places in the arch which are more liable to rupture than the remainder of the leaf. Judging from the clinical history, these congenitally weak areas may give way later in life

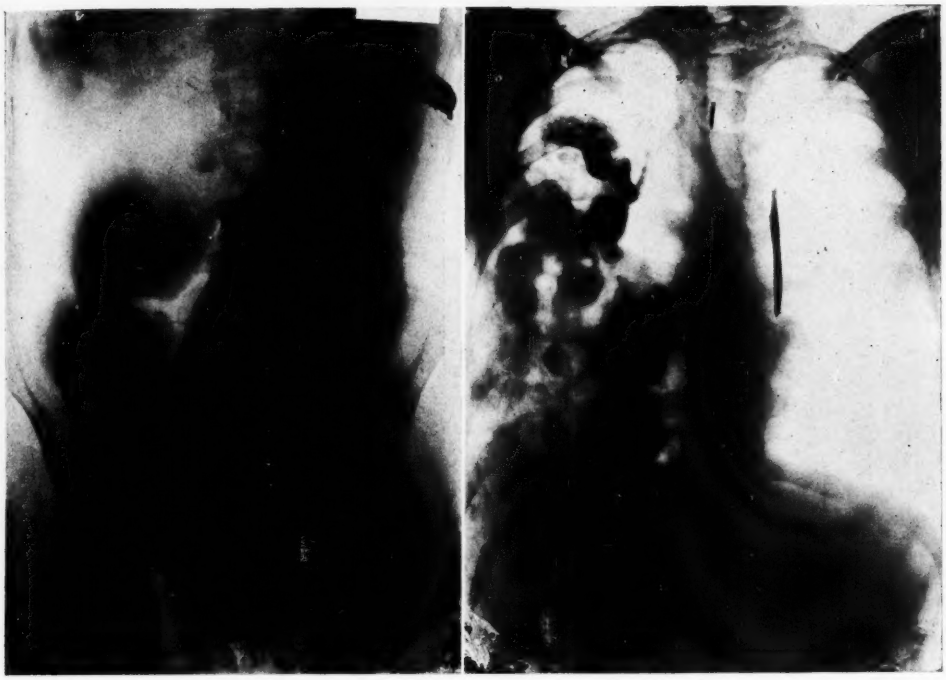

Fig. 1. Fig. 2.

Fig. 1. Case 1. Roentgenogram, showing a greatly dilated stomach filling the abdomen.
Fig. 2. Case 1. Roentgenogram, showing most of the large and small bowel in the left chest cavity.

under apparently a surprisingly slight degree of trauma. In other cases, the presence of a hernia may not give rise to any symptoms whatever until some other factor such as indiscretion of diet, physical exercise, etc., brings to light vague symptoms which stimulate a general clinical study. We do not subscribe to the opinion expressed by some of the authors who recommend routine x-ray examinations to discover defects in the diaphragm before applicants engage in certain vocations. It must be remembered that a potential defect, which may yield only under sudden or gradual strain, is not possible to demonstrate by x-ray examination. If, however, evidence of herniation is found without symptoms, it should be regarded as a very definite potential danger, and the patient should be advised accordingly. A most interesting observation is made by Rigler in pregnant women. Out of 195 cases in the trimester, he found evidence of small herniation in 18.1 per cent of multipara and in 12.1 per cent for all cases. In seven positive cases, the evidence completely disappeared after parturition.

We are certain that many small defects in the diaphragm are completely overlooked or are very difficult to detect even by the most experienced, and probably many cases complaining of vague distress in the upper abdomen may be due to small undemonstrable ruptures. The symptoms which bring the patient to seek medical aid are not always clearly related to the herniation. In the series of cases under observation, the finding of diaphragmatic eventration apparently had little or nothing to do with the clinical picture. The true hernias, on the other hand, appeared to show more definite relation to the symptomatology. The

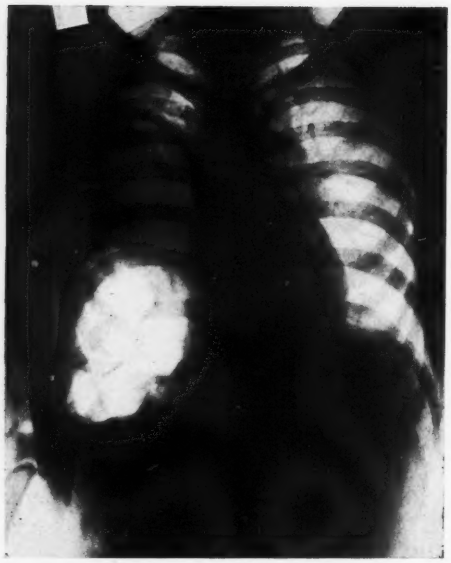

Fig. 3. Case 4. Upper pole of stomach visualized at the fifth interspace posteriorly. The heart is displaced to the right. A portion of the bowel also appears in the thoracic cavity.

Fig. 4. Case 4. Note the apparent deformity in the lower portion of the stomach, probably due to constriction (lateral view).

symptoms in some cases were so varied and irregular that they were extremely misleading.

Grosser, in a report of 433 cases from autopsy material, stated that there could be demonstrated a probable congenital basis in 232. This proportion appears to be unusually high but as this study was made before the general use of x-ray, many acquired hernias were undoubtedly overlooked. Eventration is usually included in the general group but, strictly speaking, it should be in an entirely different category; this also applies to the rare cases of congenital absence or other anomalies. Eventration is not a rupture but may be regarded as stretching or relaxation, possibly due to a phrenic nerve injury which may occur as early as birth. The other outstanding congenital condition, shortening or incomplete development of the esophagus, has been fully discussed recently by Manges and Clerf.

Several authors have reported congenital right-sided hernias which are usually observed in young children. In most cases they were discovered at postmortem. Recently this condition has come to the attention of the radiologist through the reports of Kerr and Steinberg.

In our service at the Presbyterian Hospital, Philadelphia, during the routine examination of 17,295 cases of chest and abdominal conditions, covering a period from 1922 to 1935, there were eight cases of interest from the standpoint of diaphragmatic lesion. Of these, two were undoubtedly congenital hernias (Cases 1 and 6), four could be classed as eventration (Cases 2, 3, 5, and 8), two were due to trauma (Cases 4 and 7), and of these, five were discovered without any outstanding clinical evidence (Cases 1, 2, 3, 5, and 8). Several cases were investigated for cardiac condition, some for vague indigestion or other upper abdominal distress, and a few were referred with a suspicion of the condition from clinical data. Brief summaries of the cases follow.

Case 1. Male, aged 19 years, a college student and on the track team, was tall

and thin but well nourished. Ever since a child, he had been subject to periodic stomach attacks. These spells, usually relieved by vomiting (at one time amounting to six quarts) were often blamed upon some indiscretion in diet. When the attacks became more frequent, he was referred for a gastro-intestinal examination, as a gastric ulcer or chronic appendix was suspected. The clinical study of the chest was negative.

A roentgenographic examination revealed that the abdominal cavity contained the stomach, which was unusually large, the duodenal cap being the size of a normal stomach, and the decending colon narrow, with a rather short sigmoid. The small bowel and remainder of the colon were in the left chest with the appendix directly under the zyphoid. The heart was pushed to the right, and very little of the left lung could be demonstrated. A 24-hour study showed marked retention of barium in the stomach. About a year later, an operation was performed and the diaphragm showed an opening extending from the spine outward about three inches and along the inner edge forward to the anterior chest wall, forming a triangle. Beside the small intestine, the spleen was also above the diaphragm.

COMMENT

It would appear evident that the hernia existed from early age, possibly being congenital, but as life progressed symptoms became worse, due to the gastric distress. The hernia was not suspected, either from his clinical symptoms or physical examinations.

Case 2. Female, colored, aged 45 years, suffered from a right-sided pain of three years' duration, obviously, from clinical and genito-urinary findings, due to a kidney lesion. There was no history of accidents. A physical examination pointed to the kidney but also revealed slight dullness to percussion over the left chest and distant breath sounds.

Fig. 5. Case 6. Herniation through the esophageal orifice, which did not show in the upright position.

An x-ray examination revealed an abnormal elevation of the left diaphragm, restriction of motion, and a high position of the stomach and splenic flexure. The abdominal organs did not protrude through the diaphragm.

The patient was admitted to the Jefferson Hospital and a nephrectomy was performed for hydronephrosis with extensive cortical drainage. Her recovery was uneventful.

COMMENT

The usual absence of symptoms with rather marked eventration of the left diaphragm is clearly shown. An x-ray examination quickly cleared up the reason for physical findings, but the diaphragmatic condition was purely incidental.

Case 3. A male, aged about 50 years, perfectly healthy, and about average build, was told, upon applying for more insurance, that he had some chest trouble. He was referred to his family physician, who in turn advised an x-ray study. (It is interesting to note that the same examiner for increased insurance had previously passed him.)

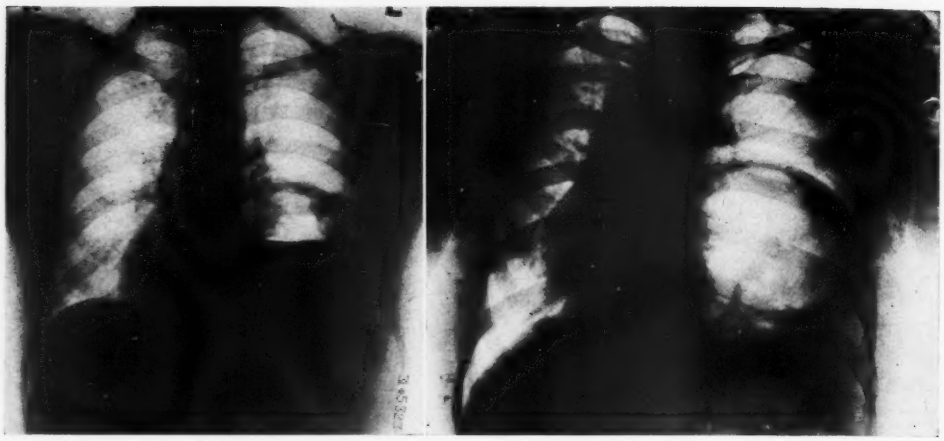

Fig. 6. Fig. 7.

Fig. 6. Case 7. Left diaphragm is elevated and immobile. The heart is pushed to the right. Parts of the stomach, bowels, and spleen are found in the left chest cavity.

Fig. 7. Case 3. The left diaphragm is elevated. The left lung is partially compressed. The heart is displaced to the right. Cases 2 and 5 showed practically the same picture, with only a slight variation of the amount of displacement.

The x-ray examination revealed a very high diaphragm on the left side. The whole stomach was above the normal position.

COMMENT

The cause and onset of the elevation of the diaphragm remain obscure.

Case 4. Colored boy, aged 19 years, was injured in an automobile accident just previous to admission. He was thrown forward, violently striking his upper left abdomen against the steering wheel. The jolt did not render the patient unconscious, but he vomited repeatedly and had violent hiccoughs. On physical examination, the left upper abdomen was rigid, and there was marked tenderness over the area of contusion. No masses were palpable, nor were there signs in the chest except restriction of movement. The heart was slightly displaced to the right, and questionable dullness was present over the lower left lobe to percussion laterally. His intra-abdominal injury was diagnosed as a possible rupture of the spleen or diaphragm.

X-ray examination revealed a dilated and deformed stomach, very high in position, and partly in the left chest cavity. The heart was displaced to the right. The left lung was somewhat compressed from the organs of the abdomen which had penetrated the left diaphragm.

Operation showed a tear of the diaphragm 6 cm. in length, running forward and toward the left from the esophageal opening. The omentum, transverse colon, and stomach were herniated. This was easily reduced, the laceration sutured, and the patient discharged shortly afterward, symptom-free.

COMMENT

Obviously a case of the acquired type, traumatic, and one of the few in which any evidence of the condition was present.

Case 5. Male, aged about 40 years, was referred from the out-patient department for a routine chest x-ray examination because of hoarseness. The patient had had a sudden onset of three weeks' duration. There was no other complaint.

A physical examination revealed râles in the lower right chest anteriorly, and questionable dullness in the right apex. No physical signs were reported over the left lung-field.

An x-ray examination showed the left diaphragm to be elevated. The heart and trachea were displaced to the right. The colon occupied a very high position.

The patient was treated in the nose and throat clinic and was later discharged.

COMMENT

The diaphragmatic finding was incidental, caused no discomfort, and was of interest only as a medical curiosity.

Case 6. Female, aged 64 years, complained of vague indigestion for four or five years, usually a half-hour after meals, severe in character, and arriving and leaving suddenly, with occasional attacks of nausea and vomiting. Her diet did not influence it. For the past six weeks, she had suffered dull epigastric distress (it became worse on exertion), insomnia, loss of 25 pounds in weight, and vomiting after nearly every meal.

A physical examination showed absolutely nothing of value. A tentative diagnosis of possible cholecystitis or gastric malignancy was made.

An x-ray examination, with the patient in the upright posture, showed an apparently normal diaphragm. In the supine posture, there was noted an indefinite protrusion of barium apparently through the esophageal orifice. In the Trendelenburg position, a large diaphragmatic hernia was demonstrated, the stomach very definitely riding above the level of the diaphragm.

An operation was advised but the patient refused and left the hospital unimproved.

COMMENT

A case of true diaphragmatic hernia without apparent cause, probably due to congenital weakness which developed late in life.

Case 7. A male, was admitted to the University Hospital in 1927 following an accident, as the result of which he received fractures of the femur, radius, and pelvis,

Fig. 8. Case 8. Roentgenogram, showing a high diaphragm and colon filled with barium enema.

with extensive third degree burns. No diagnosis was made of any chest or diaphragm pathology at that time.

In 1931 he complained of vague symptoms. An x-ray examination showed the left diaphragm to be high, at the level of the fifth posterior interspace, and immobile. The right diaphragm was freely movable. The stomach was very high; it was not definitely shown to project above the level of the diaphragm.

He was operated upon at the University Hospital, the result of which revealed a traumatic rupture of the diaphragm, with a hernia of the abdominal viscera, and a large ulcer of the stomach. The diaphragm was torn loose from its intercostal attachments so that it had barged up against the median part. At the point of the impingement upon the edge of the diaphragm some twenty feet of small intestine were extracted from the left pleural cavity, as well as the transverse and descending colon and spleen In pulling the stomach down, the ulcer which

had no stomach wall but had a base of thin peritoneum, was pulled loose. In spite of every precaution he developed peritonitis and died.

COMMENT

It is quite evident that symptoms of hernia did not exist previous to the injury. They developed gradually later, becoming worse but not severe enough to attract attention until four years had lapsed, when he was not able to carry on his daily vocation. It seems perfectly logical to presume that the injury was the cause of the hernia, which became worse until the operation was indicated. However, there may have been some weakness of the diaphragm previous to the accident.

Case 8. Colored female, aged 39 years, complained of general abdominal pain of eight months' duration. She had suffered from severe constipation and vague indigestion for many years previously.

A physical examination showed slight dullness over the left chest laterally, from the seventh rib to the base, which was thought to be due to fluid or thickening pleura. A pelvic examination showed old inflammatory disease.

An x-ray examination revealed that the splenic flexure and left diaphragm were visible at the level of the seventh rib posteriorly. There was total fixation of the left diaphragm.

COMMENT

Pelvic operation was performed with no complication. The upper abdomen was not explored.

DISCUSSION

Some authorities believe that diaphragmatic hernias are fairly common and that many are simply overlooked by inexperienced operators. It has been our practice to carefully explore the diaphragm in all examinations made of the chest or gastro-intestinal system, and with this in view, only four cases were observed in 17,295, or about one in every 4,324 cases. If those of eventration are considered, it would be one in every 2,160. In other words, the condition will be found only occasionally in the ordinary x-ray laboratory. It will also be noted that these cases of eventration have been symptomless, and in no way do they appear to inconvenience the individual, even when subjected to severe abdominal operations.

A hernia, however, is a serious matter and the symptoms are apt to be progressive; they are rather mild at the onset and become more exaggerated as time advances. The result of any operative procedure will depend entirely upon the amount of viscera displaced into the cavity of the chest, the length of time between the onset and the operation, and the character of the adhesions to the different structures.

The amount of embarrassment to respiration and the circulation is usually surprisingly small even in the severe cases. The shock following the operation and danger of infection are much more grave and must be taken into consideration.

No spontaneous cure was registered, but it would seem possible that it might occur under such circumstances as reported by Rigler. Although a number of pregnant women were examined, hernia was not found, nor were simple irregularities simulating hernias included in the list.

CONCLUSION

Most of the papers upon this subject agree that the discovery of diaphragmatic hernia, during life, is by x-ray examinations, usually made to ascertain the cause of some unusual symptoms. The number and class of cases coming under observation depend largely upon the character of the clinic and explain the wide difference of opinion in these reports.

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ABSORPTION OF X-RAYS BY LEAD GLASSES AND LEAD BARIUM GLASSES[1]

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ABSTRACT

THE results of a study of the protective properties of a group of typical flint and barium-flint glasses are reported. In chemical composition, the protective glasses analyzed were found to resemble closely the denser optical flint and barium-flint glasses. The protection coefficients of the glasses were determined by an ionization method; of the various component elements it was found that only lead and barium contribute appreciably to the protective effectiveness of the glasses.

For flint glass empirical relations were established between the protection coefficient and the chemical composition, density, and refractivity; for barium-flint glass an empirical relation is given between the protection coefficient and the lead-oxide and barium-oxide components of the glass.

I. INTRODUCTION

Gorton,[2] Dorsey,[3] and Kaye and Owen[4] have examined the x-ray protective properties of heavy flint glasses, and have correlated the protection coefficients[5] of these glasses with the glass density. However, in recent years x-ray flint glasses have been largely supplanted by x-ray barium-flint glasses which, from the point of view of protection, are essentially different. Our tests of x-ray glasses have shown that the findings of the earlier studies (References 2, 3, and 4) are not directly applicable to the newer x-ray glasses without considerable extension and modification. This is principally because barium is of lower density and lower atomic number, and, hence, has absorption properties differing from those of metallic lead. The objects of the present study of x-ray glasses were:

1. To obtain the protection coefficient of flint and barium-flint glasses as a function of x-ray quality.
2. To correlate the protection coefficient with such readily determined physical properties of glass as density and refractive index.
3. To determine the relation between the protection coefficient of the glass and its chemical composition.

II. METHODS OF DETERMINING THE PROTECTION COEFFICIENT OF A MATERIAL

The relative x-ray opacities of materials are usually determined by either a photographic or an ionization method. Inasmuch as these two methods do not always give results which are in good agreement, and this fact is not usually appreciated, a brief discussion of them will be given.

The photographic method consists in simultaneously radiographing a glass sample and a lead echelon consisting of a prepared series of lead filters. This is usually done by placing the sample and echelon side by side directly upon the cassette containing the photographic film, and exposing them to radiation. It is desirable to reduce the distance between the radiographed material and photographic film to a minimum so as to avoid overlapping of the shadows

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[1] Research Paper RP870, Part of Journal of Research of the National Bureau of Standards, March, 1936, **16.**

[2] W. S. Gorton, Am. Jour. Roentgenol., October, 1918, **5.**

[3] N. Ernest Dorsey, Am. Jour. Roentgenol., March, 1919.

[4] Kaye and Owen, Proc. Phys. Soc., London, 1923, **35,** 33D.

[5] "Protection coefficient" has been defined by the American Advisory Committee on X-ray and Radium Protection as follows:

"The 'protection coefficient' of a protective material is the ratio of the thickness of lead to the thickness of material which absorbs a given x-ray beam to the same extent."

It is to be noted that the absorption coefficient of a material is a measure of its opacity to x-rays of a given quality as compared with that of metallic lead, and, therefore, depends not only upon the absorption properties of the material itself but upon those of lead as well. It is not a measure of the absolute opacity of the material.

cast and the inclusion of uncertain amounts of scattered radiation from both test sample and lead echelon. Successive exposures on the same or different films are also undesirable, for obvious reasons. That lead filter which gives directly or by interpolation the same photographic density as the sample is taken to be the lead equivalent of the sample. From this the protection coefficient is calculated.

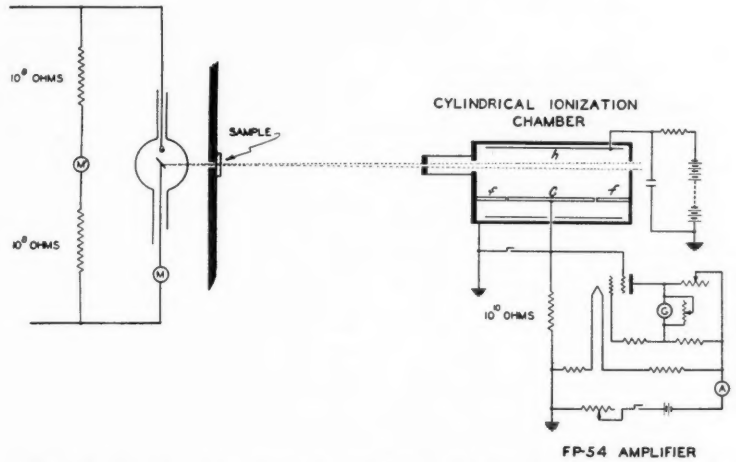

Fig. 1. Diagram of the apparatus used in determining the lead equivalent of a protective material.

The ionization method consists in comparing the current in a suitable x-ray ionization chamber obtained by using the sample as filter with the currents similarly obtained using a series of graduated lead filters. That thickness of lead which would give the same ionization current as the glass sample is then taken to be the lead equivalent of the sample.

Of these two methods, the photographic is more commonly used, since it requires a less elaborate experimental set-up. Its chief advantage is that, unlike the ionization method, a constant source of x-rays is not essential, since the exposure of both the glass sample and the standard lead echelon are made simultaneously. With the ionization method the geometrical constants of the system used in making the measurements can be adjusted so as to minimize the effect of x-ray scattering from the glass and filters under test. By decreasing the solid angle subtended by the entrance diaphragm of the ionization chamber, and by sufficiently increasing the distance between the sample under test and the chamber, this scattering can be made negligible. These adjustments are not possible with the photographic method; and consequently the protection coefficient so obtained usually differs from that obtained by the ionization method.

The result from the photographic method differs from that of the ionization method in that the former registers not only the transmitted radiation but in addition the secondary radiation from the material. Although it is true that from the point of view of protection, there is no need to distinguish between transmitted and scattered radiation from a protective material, it is desirable to separate the two factors, absorption and scattering. Unless this is done, a reproducible measure of the lead equivalent or protection coefficient of a material is more or less doubtful. Moreover, since the secondary radiation from glass has a different spectral composition than that of metallic lead, it is questionable whether two such different radiations can be satisfactorily compared by photographic means. Little is known concerning the variation

in photographic sensitivity with x-ray quality, and in the absence of definite information on this point, it is unsafe to assume that the sensitivity of the emulsion used is not a function of wave length.[6]

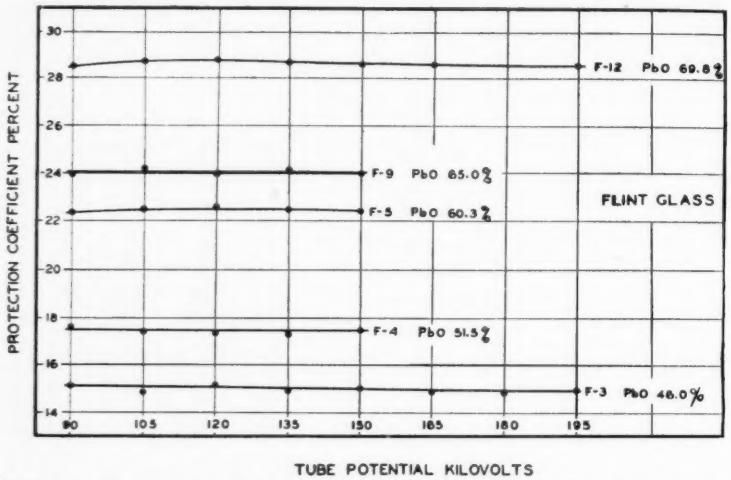

Fig. 2. The variation of the protection coefficient of flint glass with x-ray tube potential.

III. EXPERIMENTAL PROCEDURE

The ionization method and experimental arrangement sketched in Figure 1 were used here. For measuring the relative absorption properties of materials the cylindrical ionization chamber is better suited than is the parallel-plate ionization chamber commonly used in dosage standardization. The x-ray intensities which must be measured in opacity tests are necessarily very low; for most of those here reported the radiation intensity after filtration is about 10^{-4} times that of the incident radiation. It is desirable to have the volume of air ionized large enough to furnish ionization currents that are not troublesomely small. However, an increase in this volume augments at the same time the interelectrode capacity and the collector-to-ground capacity of the system, and the effect of both is to increase the period of the system and to produce an uncertain galvanometer zero because of induced currents resulting from random fluctuations in the potential difference between the high potential electrode and ground.

The ionization chamber used is of the cylindrical open-air type. It consists of a thin aluminum cylinder electrode (*h*) spaced by hard rubber posts from a concentric supporting brass tube 30 cm. in diameter and 60 cm. long, closed at the ends with aluminum. The edges of this electrode are somewhat rounded and separated several centimeters from the ends of the supporting cylinder so as to minimize field distortion. The collector electrode is a brass cylinder (*c*) about 1 cm. in diameter and 30 cm. long. Guard cylinders (*f*) of the same diameter extend to the earthed ends of the chamber. The chamber is covered with one-eighth inch of lead throughout, with an additional one-eighth inch thickness on the front face.

The distance from the middle of the collector electrode to the tube target is 147 cm., and from the middle of the collector to the sample 74 cm.

The ionization current is measured by means of a balanced[7] direct current amplifier, using an F.P.-54 electrometer tube. The amplifier output is measured by means

[6] R. B. Wilsey, Am. Jour. Roentgenol. and Rad. Ther., 1935, **32**, 789.

[7] Lee A. DuBridge and Hart Brown, Rev. Sci. Inst., 1933, **4**, 532.

of a galvanometer having a current sensitivity of 5.7×10^{-9} ampere per millimeter and a period of 3 seconds. The over-all sensitivity of the system is 7.4×10^{-15} ampere per millimeter and the current amplification is 7.7×10^{5}. Under these conditions the stability of the galvanometer zero is satisfactory; the observed zero drift being no greater than 1 mm. per hour from 30 to 60 minutes after closing the amplifier battery circuit. However, under the working conditions where the electrodes of the ionization chamber are charged two conditions combine to produce an unsteady zero. The first is a short period fluctuation of from 1 to 2 mm. resulting from random bursts of ionization caused by alpha particles originating in traces of radio-active impurities[8,9] in the electrodes, and from radio-active contamination of the free air within the chamber. Because of their short period these fluctuations are readily distinguished from those resulting from variations in the x-ray input to the ionization chamber; and therefore they do not seriously affect the accuracy with which a given deflection can be read. A more serious cause of uncertainty in the galvanometer zero is the irregular displacement current produced in the ionization chamber by random fluctuations in the potential difference between the electrodes arising from variations in the emf. of the high voltage supply. The inter-electrode capacity of the chamber used is only 53 $\mu\mu$f, but a sudden variation of 0.1 volt in the potential difference produces a displacement current which registers a deflection of 30 mm. at full sensitivity. Since 1,000 volts are required for saturation, it is evident that an extremely constant high voltage supply is essential. Large B batteries in good condition are satisfactory.

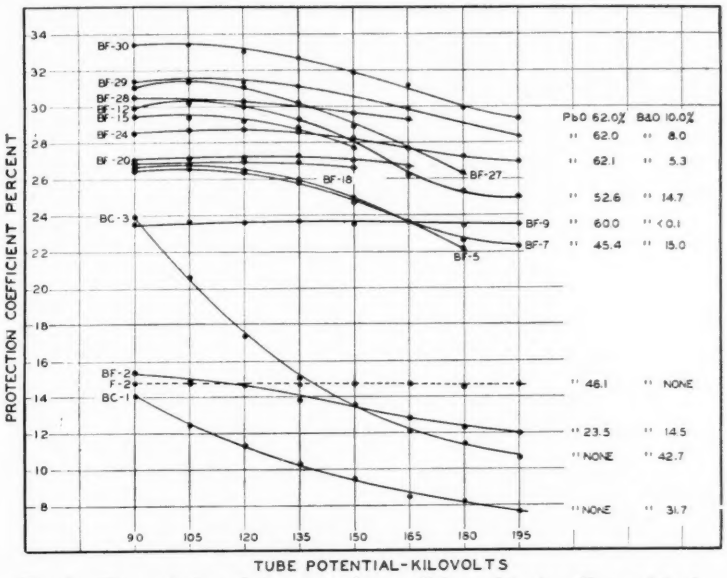

Fig. 3. The variation of the protection coefficient of barium-flint and barium crown glass with x-ray tube potential.

The ionization current was measured by direct deflection. Inasmuch as ionization readings for both metallic lead and for glass are here directly compared any variation from linear amplification[10] in this system does not affect the results.

[8] J. A. Bearden, Rev. Sci. Inst., 1933, **4**, 271.
[9] Ziegert, Ztschr. f. Phys., 1927, **46**, 668.

[10] The ratio between output current and input current for the system used varies from a straight line by approximately 1 per cent for deflections up to the maximum obtained. Where strictly linear amplification is essential, it is necessary to operate the electrometer tube on a fixed point of its plate current-grid

X-rays were generated by means of a thick wall therapy x-ray tube supplied with power by a 200-kv. constant potential generator previously described.[11] The

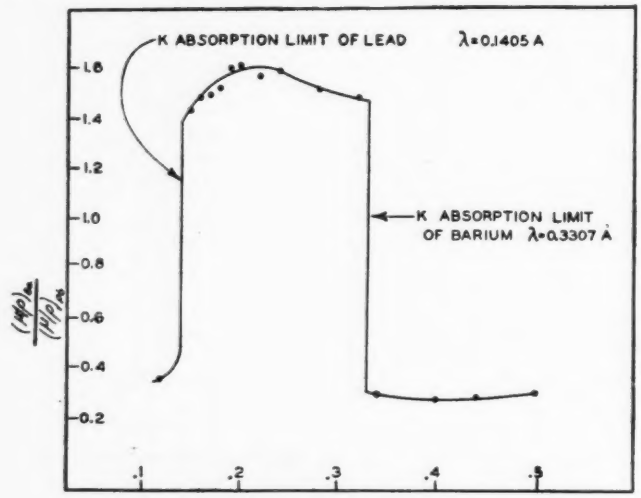

Fig. 4.

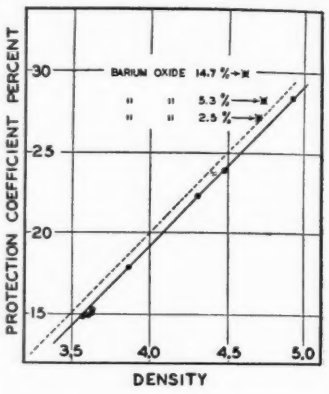

Fig. 5.

Fig. 4. The ratio of the mass absorption coefficients of barium and lead as a function of the effective wave length of a narrow spectral band of x-radiation.

Fig. 5. The protection coefficient of flint glass as a function of the glass density.

power supply input is stabilized; variations in power input being not greater than ±0.3 per cent. The cathode of the x-ray tube was heated by storage batteries. Both tube voltage and current were continuously observed and controlled by the operator from his station near the amplifier. It is estimated that variations in x-ray input to the ionization chamber did not exceed ±0.5 per cent. When the x-ray generator is manually controlled these variations are reduced to approximately ±0.25 per cent. The potential difference across the x-ray tube was read directly by means of an accurately calibrated, high resistance voltmeter[12] consisting of a microammeter in series with two resistance units of 100 megohms each.

potential characteristic. This is best done by the introduction of a potentiometer in the grid circuit, and the use of the system as a null instrument.

[11] L. S. Taylor, Bureau of Standards Jour. Research, 1929, **2**, 771, RP56.

[12] L. S. Taylor, Bureau of Standards Jour. Research, 1930, **5**, 609, RP217.

IV. DESCRIPTION OF GLASSES

Commercial x-ray protective glasses now available are of two kinds:

1. Dense flint glasses whose x-ray protective qualities are practically determined by their lead content alone.

2. Barium-flint glasses whose effectiveness arises from the presence of both lead and barium.

Other constituents of both types of x-ray glasses are of comparatively low atomic number and hence do not contribute much to the protective qualities of these materials. The recent trend in x-ray glasses has been toward those of higher protection coefficient, that is, from the flint to the barium-flint glasses. Although the former are now relatively unimportant commercially as a protective product, they are here of interest as a means of understanding the newer barium-flint x-ray glasses.

This report is based on a study of 30 glasses obtained from a number of different sources. Of these, 22 are commercial x-ray glasses selected from a group of 53 as being representative of protective x-ray glasses commercially available at the present time.

For the purpose of comparison, eight standard optical glasses were included; six of these were obtained from the Glass Section of this Bureau.

Although lead and barium are the effective components of protective glasses, it is convenient in considering the protective properties of these glasses to consider the protection coefficient as a function of the oxides of these metals rather than of the metals themselves.

In Tables I and II there are listed all flint and barium-flint x-ray glasses studied, together with such of their chemical and physical properties as are of interest in connection with this study.[13] The classification of each glass is given in column 2. BC–1, BC–2, and BC–3 of Table II are optical barium crown glasses, not used for x-ray protection, but included here for pur-

[13] We are indebted to J. I. Hoffman for checking the chemical analyses of the glasses listed; to L. W. Tilton for all refractivity measurements, and to E. L. Peffer for all density determinations.

TABLE I.—LIST OF FLINT GLASSES

Glass	Classification	No. Samples of Each Glass	Refractive Index n_D	Density	PbO	BaO	Protection Coefficient (Per Cent) for—						
							90 kv.	105 kv.	120 kv.	135 kv.	150 kv.	165 kv.	195 kv.
					%	%							
F-1[c]	Commercial x-rays	2	1.618	3.609	46.1	0.0	14.96	14.93	15.06	14.94	15.11	14.84	14.72
F-3[b]	Optical flint	1	1.622	3.630	46.0	0.0	15.13	14.96	15.17	14.90	15.03	14.88	14.94
F-4[b]	Optical flint	1	1.647	3.859	51.5	0.0	17.84	17.43	17.53	17.49	17.55	17.35	17.25
F-5[a]	Commercial x-rays	2	1.700	4.310	60.3	0.0	22.30	22.43	22.51	22.43	22.32	22.60	22.51
F-9[a]	Commercial x-rays	1	1.721	4.479	65.0	0.0	23.92	24.20	23.99	24.13	23.99	...	...
F-12[b]	Optical flint	1	1.775	4.932	69.8	0.0	28.42	28.66	28.77	28.66	28.62	28.52	28.50

[a] Chemical analyses submitted by manufacturer.
[b] Batch analyses submitted by Mr. Finn of NBS Glass Section.
[c] Chemical analysis made by Mr. Hoffman of NBS Chemistry Division.

TABLE II.—LIST OF BARIUM-FLINT AND BARIUM CROWN GLASSES

Glass	Classification	No. Samples of Each Glass	Refractive Index n_D	Density	PbO	BaO	Protection Coefficient (Per Cent) for—						
							90 kv.	105 kv.	120 kv.	135 kv.	150 kv.	165 kv.	195 kv.
					%	%							
BF-1[a]	Optical barium-flint	1	...	3.392	6.87	29.15	...	...	...	...	...	9.89	8.89
BF-2[b]	Optical barium-flint	1	1.603	3.479	23.5	14.5	15.35	14.86	14.62	13.79	13.56	12.75	11.93
BF-3[c]	Commercial x-ray	2	1.614	3.572	44.1	<.1	14.80	14.78	14.81	14.66	14.74	14.81	14.72
BF-5[c]	"	2	1.6949	4.323	47.1	14.35	26.43	26.56	26.31	25.76	24.65	...	21.56
BF-7[a]	"	2	1.6992	4.361	45.38	15.02	26.60	26.90	26.46	25.96	24.93	23.57	22.26
BF-9[c]	"	3	1.7146	4.423	60.0	<.1	23.49	23.63	23.58	23.64	23.48	...	23.43
BF-12[c]	"	2	1.723	4.587	52.0	13.94	29.42	29.38	29.14	28.61	27.70	...	...
BF-14[a]	"	1	...	4.604	53.15	13.01	29.98	29.74	29.22	28.80	27.73	26.17	24.90
BF-15[a]	"	2	1.7254	4.609	52.6	14.7	29.88	30.15	29.83	29.27	28.20	26.05	25.02
BF-17[a]	"	1	...	4.609	51.2	15.5	...	29.7	...	...	28.0	...	...
BF-18[c]	"	2	1.741	4.690	62.2	2.34	26.88	26.88	26.94	26.90	26.57	...	...
BF-20[c]	"	1	1.742	4.698	61.6	2.52	27.01	27.11	27.17	27.24	26.99	26.63	26.41
BF-22[a]	"	2	1.7396	4.712	60.9	6.5	28.43	28.62	28.64	28.54	27.91	27.54	26.81
BF-24[a]	"	2	1.7428	4.734	62.1	5.3	28.27	28.69	28.49	28.42	27.85	27.63	27.08
BF-27[ad]	"	1	...	4.837	52.6	14.6	31.02	31.30	31.09	30.22	28.80	28.09	26.23
BF-28[ae]	"	1	...	4.856	62.0	5.3	30.50	30.29	30.27	30.19	29.60	29.29	28.25
BF-29[a]	"	1	...	4.906	62.0	8.0	31.37	31.30	31.30	31.01	30.14	29.83	28.44
BF-30[a]	"	1	...	5.055	62.0	10.0	33.38	33.39	32.97	31.67	31.69	31.16	29.25
BF-31[a]	"	1	...	...	61.0	9.7	...	32.0	...	30.6	...	...	28.4
BC-1[b]	Optical barium crown	1	1.572	3.205	0.0	31.7	14.03	12.41	11.28	10.23	9.45	8.45	7.62
BC-2[a]	"	1	...	3.513	0.0	38.40	...	...	...	...	...	10.04	8.71
BC-3[b]	"	1	1.606	3.701	0.0	42.7	23.94	20.60	17.31	14.95	13.52	12.05	10.56

[a] Chemical analyses submitted by manufacturer.
[b] Batch analyses submitted by Mr. Finn of NBS Glass Section.
[c] Chemical analyses made by Mr. Hoffman of NBS Chemistry Division.
[d] Glass BF-27 contains 5 per cent of TiO_2.
[e] Glass BF-28 contains 2 per cent of UO_3.

poses of comparison. The chemical analyses given for PbO and BaO content were obtained mostly from the glass manufacturers. In several cases our measurements of the opacity to x-rays indicated that the manufacturer's analysis must be in error. In each of these a chemical analysis made by Mr. Hoffman at this Bureau confirmed our views; and for these Mr. Hoffman's analyses are recorded instead of those given by the manufacturer.

It should be noted that the commercial x-ray glasses of both the flint and barium-flint types are very similar in their chemical and physical properties to the typical optical glasses of these types. The x-ray glasses are different only in that their content of lead and barium oxide is, in general, greater.

V. PROTECTION COEFFICIENT AND QUALITY OF RADIATION

The manner in which the protection coefficient of a glass depends upon the quality of the incident x-radiation is of particular interest. If there is a marked variation in the protection coefficient of a glass as the x-ray quality is varied, the coefficient determined for any one quality may be quite adequate for calculating the glass thickness required to meet x-ray safety recommendations[14] for that particular radiation but may be dangerously inadequate for a corresponding calculation for radiation of another quality. In such a case it is obviously meaningless to speak, as is often done, of the protection coefficient or lead equivalent of the glass unless the quality of radiation for which the coefficient applies is also specified.

The protection coefficient of a flint glass, which depends for its protective quality almost wholly on its lead content, is, in general, independent of the radiation quality. This is apparent from Figure 2 in which the protection coefficient of the glasses listed in Table I is plotted as a function of the excitation potential on the x-ray tube. Here the locus of the protection coefficient of any one flint glass is nearly a horizontal straight line. For most glasses of this type there appears to be a very slight, though negligible, maximum at about 105 kv., which is probably due to the light oxide components of the glass.

As shown in Figure 3, the protection coefficient of a barium-flint glass, in contrast with that of a flint glass, is not independent of radiation quality. The protection coefficient here yields a curve with a maximum at about 105 kv., irrespective of the amount of barium present. The accentuation of the maximum increases, however, with the increase of barium content, glasses containing relatively large quantities of BaO having the most marked maxima. For barium crown glasses, such as BC–1 and BC–3, the variation of protective coefficient with radiation quality is most marked. The maxima for these glasses are not shown since they lie below the tube-voltage ranges used.

A comparison between the protection coefficient of a flint and a barium-flint glass containing the same percentage of PbO is of interest in that effectiveness of the BaO component of the barium-flint glass then becomes apparent. In order to facilitate such a comparison, the protection coefficient curve of a flint glass, F–2, having about the same PbO content as barium-flint BF–7, has been included in Figure 3. Although this is a typical case, other examples are available between glasses listed in Tables I and II. Comparing curves, F–2 and BF–7 reveals that the protection coefficient of a barium-flint glass is considerably greater than that of a flint glass containing the same percentage of PbO. This difference is especially marked in the vicinity of the maximum for 105-kv. x-rays, but with increasing hardness of the radiation the difference in coefficients diminishes.

It is obvious that the protection coefficient of a barium-flint glass cannot be less than that of a flint glass containing the same percentage of PbO. This point is of practical interest, since it defines the lower limit of the protection coefficient of a barium-flint glass in terms of the protection coefficient of a flint glass containing

[14] Bureau of Standards Handbook 15, 1931.

the same PbO component. The protection coefficient of the latter glass does not vary appreciably with voltage and is readily determined from any one of several physical and chemical properties of the glass.

VI. PROTECTION COEFFICIENT OF GLASS FOR A NARROW SPECTRAL BAND OF RADIATION

1. *Flint Glass*

In order to understand the characteristic differences between x-ray glasses of the flint and barium-flint types described in the preceding section, it is convenient to set up equations for the protection coefficient of a glass as a function of the absorption coefficients of its component elements. To do so, it is necessary to make assumptions concerning experimental conditions which in practice cannot be rigorously fulfilled. These assumptions are:

1. That the radiation for which the coefficient is defined is homogeneous in frequency.

2. That the filters used are so thin and the x-ray beam so collimated that all incident rays traverse equal thicknesses of filter.

3. That the filter thickness is so small that the effective wave length of the radiation is not appreciably altered by filtration when the radiation used is not strictly homogeneous with respect to frequency.

The first of these conditions is never fulfilled; x-ray glasses are intended primarily for protection against heterogeneous radiation, and tests are made using such radiation. However, as is already evident from Figure 2 and the discussion of the preceding section, the wave length effect is very small for flint glasses and it may, therefore, be expected, as is indeed the case, that for such glasses the protection coefficient calculated for a narrow spectral band of radiation is a satisfactory approximation of the experimentally determined value for heterogeneous radiation. For barium-flint glasses the case is, however, quite different since there is considerable variation in protection coefficient with variation in radiation quality. Consequently the protection coefficient for barium-flint glasses calculated for a narrow spectral band is difficult to interpret and is not directly comparable with the experimental value. However, even for barium-flint glasses the equations derived for a narrow spectral band of x-rays are valuable in that they reveal the relation whereby the protection coefficient changes with variation in radiation quality.

The second assumed condition can be approximated in practice, as has here been done, by diaphragming the beam so that for all rays there is little difference in pathlength through the filter.

The glass filters used were approximately one-fourth inch thick. Since filters of such thickness harden the incident heterogeneous radiation considerably, the further assumption is involved that the quality changes resulting from filtration through the corresponding thickness of metallic lead and through glass are identical.

Let a beam of a narrow spectral band of radiation of intensity I_o, be reduced to intensity I, on traversing a glass sample of thickness X_{gl}. Now let a filter of metallic lead be selected of such thickness, X_{Pb}, that it, also, will reduce the intensity of the x-ray beam from I_0 to I. Then

$$I = I_0 e^{-\mu_{gl} X_{gl}} = I_0 e^{-\mu_{Pb} X_{Pb}}, \qquad (1)$$

where μ_{gl} and μ_{Pb} are respectively the linear-absorption coefficients of the glass sample and the metallic lead filter for the x-radiation in question. From Equation 1 and the definition of the protection coefficient (C),[15] it follows that:

$$C = \frac{X_{Pb}}{X_{gl}} = \frac{\mu_{gl}}{\mu_{Pb}} = \frac{\mu_{gl}}{(\mu/\rho)_{Pb} \cdot \rho_{Pb}}, \qquad (2)$$

where $(\mu/\rho)_{Pb}$ is the mass absorption coefficient for lead for the x-radiation in question, and $\rho_{Pb} = 11.34$ is the density of lead. Since the mass absorption coefficient of an element is essentially independent of its physical or chemical state,[16] it is possible to express the linear absorption coefficients of the glass sample, μ_{gl}, in terms of the mass absorption coefficients of its several

[15] See Footnote 5.

[16] See, for example, Int. Crit. Tables, 1929, **6**, 12.

component elements, $(\mu/\rho)_1$, $(\mu/\rho)_2$, etc., as follows:

$$\mu_{gl} = \rho_{gl}[P_1(\mu/\rho)_1 + P_2(\mu/\rho)_2 \ldots . P_n(\mu/\rho)_n], \quad (3)$$

where P_1, P_2, P_3, etc., are the ratios of the mass of each component to the total mass of the glass; $(\mu/\rho)_1$, $(\mu/\rho)_2$, etc., are the mass absorption coefficients of these components; and ρ_{gl} is the glass density. Equation 2 then becomes:

$$C = \frac{\rho_{gl}}{\rho_{Pb}}\left[P_1\frac{(\mu/\rho)_1}{(\mu/\rho)_{Pb}} + P_2\frac{(\mu/\rho)_2}{(\mu/\rho)_{Pb}} \ldots P_n\frac{(\mu/\rho)_n}{(\mu/\rho)_{Pb}}\right]. \quad (4)$$

Since lead is the most important component in all protective x-ray glasses, it is convenient to rewrite Equation 4 as follows:

$$C = \frac{\rho_{gl}}{\rho_{Pb}} \cdot P_{Pb} + \frac{\rho_{gl}}{\rho_{Pb}}\left[P_2\frac{(\mu/\rho)_2}{(\mu/\rho)_{Pb}} + P_3\frac{(\mu/\rho)_3}{(\mu/\rho)_{Pb}} \cdots \cdots P_n\frac{(\mu/\rho)_n}{(\mu/\rho)_{Pb}}\right]. \quad (5)$$

By means of Equation 5 it is possible to calculate the protection coefficient C of any glass for a narrow spectral beam of radiation, having given the composition and density of the glass and the mass absorption coefficient of each component element for that radiation. The total protection coefficient C is expressed as the sum of two quantities: The first of these gives the component of the total coefficient due to the metallic lead contained in the glass; the second is the component of the total coefficient due to the presence of all component elements other than lead. The first right-hand term involves no quantity which varies with the quality of the incident radiation; the second involves the mass absorption coefficient of metallic lead and of each element contained in the glass, all of which are functions of radiation quality. It is, therefore, to be expected that the protection coefficient of any glass is independent of radiation quality only to the extent that the component of the total protection coefficient due to elements other than lead is negligibly small as compared with that due to the lead content of the glass.

That the component of the total protection coefficient due to elements other than lead is small for flint glass is evident from Table III. Here the protection coefficients of four flint glasses as calculated by means of Equation 5 for wave lengths 0.098 and 0.710 Å. are compared with the experimentally determined values for 90 and 150 kv. The calculated coefficients given in columns 3 and 4 are lower than the experimentally determined values of columns 5 and 6. The agreement, however, becomes satisfactory for the denser flint glasses. It should be noted that glasses F–3 and F–4 are optical flint glasses, which are lighter than most x-ray glasses of this type. They are included here because it was desired to test the validity of Equation 5 for glasses lying immediately outside the range of typical x-ray glasses. Glass F–5 is a typical x-ray flint. Glass F–12 is a very dense optical flint, heavier than any x-ray flint tested. In columns 6 and 7 of Table III there is given for each glass the fraction of the calculated protection coefficient due to glass components other than metallic lead. For the dense flint glasses the total contribution of all elements other than lead is small, being of the order of 2 or 3 per cent.

TABLE III.—PROTECTION COEFFICIENTS OF FOUR TYPICAL FLINT GLASSES AS CALCULATED BY EQUATION 5 COMPARED WITH EXPERIMENTALLY DETERMINED VALUES

1	2	3	4	5	6	7	8
Glass	PbO	Protection Coefficient (Per Cent)				Fraction of Total Calculated Coefficient Due to Components of Glass Other than Lead for	
		Calculated for[a]		Observed for			
		λ = 0.098 Å.	λ = 0.710 Å.	150 kv.	90 kv.	λ = 0.098 Å.	λ = 0.710 Å.
	Per Cent						
F-3.....	46.0	14.5	14.3	15.0	15.1	0.055	0.044
F-4.....	51.5	17.1	16.9	17.6	17.8	.046	.036
F-5.....	60.3	22.1	21.8	22.3	22.3	.035	.026
F-12.....	69.8	28.6	28.6	28.6	28.4	.012	.014

[a] The mass absorption coefficients used in these calculations were taken from data tabulated by Compton and Allison, X-rays in Theory and Practice, p. 800. D. Van Nostrand Co., Inc., New York, 1935.

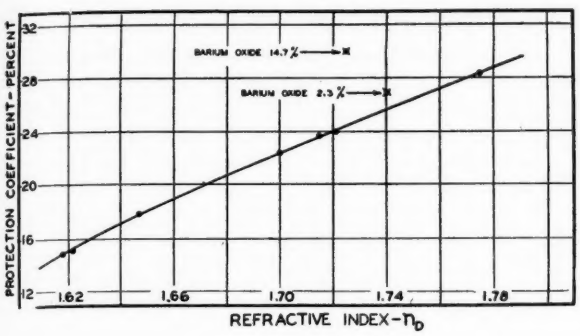

Fig. 6.

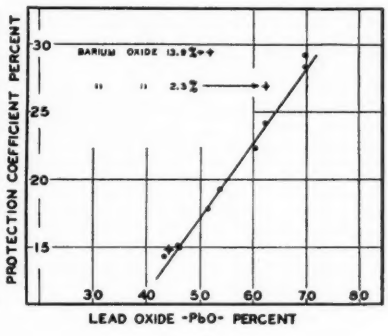

Fig. 7.

Fig. 6. The protection coefficient of flint glass as a function of the refractive index of the glass.
Fig. 7. The protection coefficient of flint glass as a function of the percentage of lead oxide (PbO) contained in the glass.

If it is, therefore, assumed that for heavy flint glass the effect on the coefficient of all elements other than lead is negligible, Equation 5 can be simplified by dropping the second term, which gives:

$$C = \frac{\rho_{gl}}{\rho_{Pb}} P_{Pb} . \qquad (6)$$

Equation 6 then gives an approximation for the protection coefficient of a heavy flint glass simply in terms of the percentage of lead it contains, the glass density, and the density of lead. Since the density of lead is 11.34 and that of heavy flint glass about 4, it follows that for such glasses the protection coefficient is roughly equal numerically to one-third the percentage of lead contained. The statement is occasionally made that a flint glass containing, say, 60 per cent of lead will have a protection coefficient of 60 per cent; but this is not to be expected from Equation 6; and that it is not true is evident from any one of the curves given in Figure 2. By means of Equation 5 the chief characteristics of flint glass as a protective material (as found experimentally) can be explained, namely:

1. The protection coefficient of a flint glass is practically independent of radiation quality.

2. All elements contained in a flint glass other than lead contribute little to the value of the glass as a protective material.

2. *Barium-flint Glass*

It has already been noted in connection with the discussion of Figure 3 that a barium-flint glass has an appreciably greater protection coefficient than a flint glass containing the same percentage of lead oxide. This is to be expected since the atomic number of barium (56) is considerably greater than that of most elements found in glass; however, the marked protective effectiveness of barium for heterogeneous radiation of about 105 kv. cannot be attributed to this cause alone. It is convenient to rewrite Equation 5 for a barium-flint glass as follows:

$$C = \frac{\rho_{gl}}{\rho_{Pb}} \cdot P_{Pb} + \frac{\rho_{gl}}{\rho_{Pb}} \left(P_{Ba} \cdot \frac{(\mu/\rho)_{Ba}}{(\mu/\rho)_{Pb}} \right) + \frac{\rho_{gl}}{\rho_{Pb}} \sum \frac{(\mu/\rho)_r}{(\mu/\rho)_{Pb}} \qquad (7)$$

where P_{Ba} is the fraction of total mass of glass which is barium, having a mass absorption coefficient $(\mu/\rho)_{Ba}$. Since the percentage of the light elements (those other than barium and lead) in an x-ray barium-flint glass is less than that in a flint glass containing the same percentage of lead, it is to be expected that the contribution toward the protection coefficient made by the lighter components is even less in a barium-flint than in a flint glass having the same percentage of lead. If we, therefore, assume the effect of the elements other than lead and barium to be negligible, Equation 7 becomes

$$C = \frac{\rho_{gl}}{\rho_{Pb}} \left(P_{Pb} + P_{Ba} \cdot \frac{(\mu/\rho)_{Ba}}{(\mu/\rho)_{Pb}} \right) . \qquad (8)$$

From this, it is evident that the protection coefficient of a barium-flint glass must depend upon the quality of the incident radiation since the mass absorption coefficients

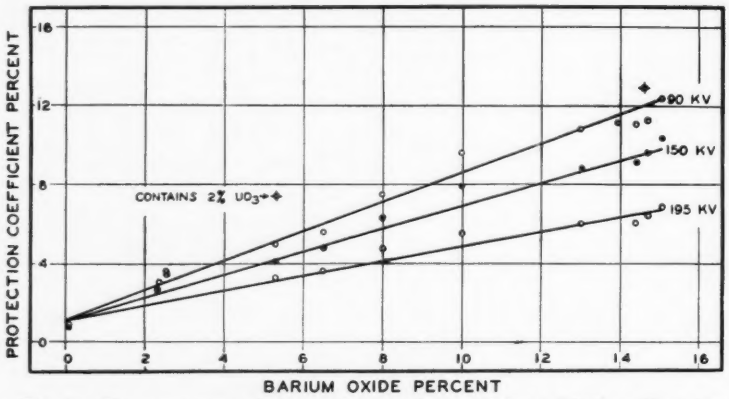

Fig. 8. The component of the total protection coefficient of barium flint glass due to all elements of the glass other than lead plotted as a function of the percentage of barium oxide (BaO) contained in the glass.

of both lead and barium are involved, both of which are functions of wave length; moreover, the wave length effect must vary with the percentage of barium (P_{Ba}) contained in the glass, as has already been noted in connection with the experimentally determined value. The nature of this dependence is evident from a consideration of the manner in which the mass absorption coefficient of an element varies with effective wave length of a narrow spectral beam. At the critical absorption limits of both lead and barium, there are discontinuities in their respective absorption coefficients, and since these discontinuities occur at different wave lengths, it is evident that there must be distinct discontinuities in the protection coefficient of a glass containing barium. Of particular interest are the discontinuities of these elements at their respective K absorption limits, which, for lead, occur at 0.1405 Å. and for barium at 0.3307 Å. As the x-ray tube voltage is increased, the K absorption limits of barium are approached from the long wave length side, and at this limit the mass absorption coefficient of barium is increased about sixfold. The composite protection coefficient as given by Equation 8 will, therefore, be correspondingly increased. As the tube voltage is increased further, the critical absorption limit of lead is reached at which the absorption coefficient of lead is approximately doubled. For radiation of this quality, the protection coefficient will, therefore, be decreased since the mass absorption coefficient of lead occurs in the denominator of Equation 8. As a result of these discontinuities the protection coefficient of a glass containing barium should have a maximum value in the interval 0.1405 Å. $<\lambda>$ 0.3307 Å. In Figure 4 the ratio of the mass absorption coefficient of barium to that of lead has been plotted as a function of wave length for a narrow spectral band of radiation.

For heterogeneous radiation, no distinct discontinuities in the protection coefficient, such as shown in Figure 4, are to be expected. However, since any heterogeneous beam having a minimum wave length less than 0.1405 Å. has some radiation lying in the above-mentioned interval, the effect of the barium component in the glass is to increase the protection coefficient. The actual increase depends upon what fraction of the total energy of the composite beam falls within the interval 0.1405 Å. $<\lambda>$ 0.3307 Å. As the x-ray-tube voltage is increased above 105 kv. less and less of the total energy of the beam falls within this interval and the protection coefficient is correspondingly decreased, as has already been noted from the experimental data. This effect is

particularly noticeable in barium crown glasses, such as BC–1 and BC–3 of Figure 3.

VII. EMPIRICAL RELATIONS FOR PROTECTION COEFFICIENT OF FLINT GLASS

As already noted, the theoretical relations derived for the protection coefficient of glass are limited in their practical usefulness by the simplifying assumptions necessary for their derivation, the most formidable of which is the assumption that the x-radiation is homogeneous. Because of these limitations, empirical relations between the protection coefficient and such properties of the glass as density, refractive index, and lead-oxide and barium-oxide content are desirable. Then, when any one of these properties is known, it may be possible to predict the protection coefficient of a typical x-ray protective glass from these empirical relations without actually determining the protection coefficient experimentally. The values so obtained agree with the accurately determined experimental value to within a few per cent and are usually as good as the experimental value obtainable with the apparatus and equipment in the average x-ray laboratory.

It is comparatively easy to find empirical relations for a typical x-ray glass which contains only PbO as an effective component; for a barium-flint x-ray glass the problem is complicated by the presence of an additional component, BaO.

1. Protection Coefficient and Density

The relation between the protection coefficient and the density of a flint glass is given in Figure 5 for typical x-ray glasses ranging in density from 3.61 to 4.93. Over this range, the protection coefficient is found to be a linear function of the glass density, given by the equation:

$$C = 10\rho_{gl} - 20.8; \quad 3.61 < \rho_{gl} < 4.93, \qquad (9)$$

where again C is the protection coefficient and ρ_{gl} the glass density. This is in substantial agreement with a similar equation by Kaye,[17] derived from a study of flint glasses ranging in density from 3.2 to 4.8.

[17] G. W. C. Kaye, Roentgenology, p. 89. Paul B. Hoeber, Inc., New York, 1929.

Equation 9, based on data obtained here for 90-kv. radiation, holds, within the experimental error, for radiations up to 195 kv. The values for C so obtained are about 3 per cent lower than Kaye's. The effect of a small barium-oxide component may be noted from the points plotted also in Figure 5 for glasses containing small quantities of barium oxide.

2. Protection Coefficient and Refractive Index

In Figure 6 the protection coefficient of each flint glass studied has been plotted against the refractive index of the glass obtained for the D line of sodium. The effect of a small barium component in increasing the protection coefficient is again apparent. Inasmuch as the refractive index of a glass is readily determined, the curve of Figure 6 is a very convenient means for determining the protection coefficient of a flint glass.

3. Protection Coefficient and Chemical Composition

Figure 2 indicates that in general the protection coefficient of a flint glass depends upon the PbO contained in the glass and increases as this component is increased. Figure 7 shows the more exact nature of this dependence, as made evident by replotting the same data with the protection coefficient as ordinate and the PbO content of the glass as abscissa. The closed circles represent experimental data obtained for flint glasses listed in Table II. The open circles are points obtained by means of Equation 9 from Wright's[18] collected data on the relation between the density and the PbO content of optical flint glasses. The crossed circles are for x-ray glasses containing small amounts of BaO. It appears that the protection coefficient of a flint glass is an increasing function of the percentage of lead oxide. This function is not exactly linear but for a PbO component ranging from 46 to 70 per cent, it can be satisfactorily approximated by the straight line equation:

[18] The Manufacture of Optical Glass and of Optical Systems, p. 60, Ordnance Dept. Document 2037 (U. S. Government Printing Office, Washington, D. C., 1921).

$$C = 0.553(P_{PbO} - 19); \quad 46 < P_{PbO} < 70, \qquad (10)$$

where P_{PbO} is the per cent of PbO contained in the glass. X-ray glasses commercially available fall well within the range of PbO components for which this linear approximation is satisfactory.

In Table IV the experimentally determined protection coefficients for 90- and 150-kv. x-rays of all flint glasses studied are compared with the coefficient calculated by means of Equation 10.

VIII. EMPIRICAL RELATIONS FOR BARIUM-FLINT GLASS

1. *Effect of Added Barium Oxide on Protection Coefficient*

That there is a marked increase in the protection coefficient of an x-ray glass when BaO is added has already been noted in the discussion of Figure 3. Some idea of the effectiveness of even a very small BaO component in an x-ray glass can be obtained from Figure 7 in which, for 90-kv. radiation, the two points with crosses are for glasses containing 2.3 and 13.9 per cent of BaO in addition to their PbO component. It is apparent that for radiation of this quality, as little as 0.5 per cent of BaO results in an appreciable increase in the protection coefficient of the glass. For more penetrating radiation the effect of the BaO component is less, but is still appreciable.

TABLE IV.—FLINT GLASSES

Glass	Classification	PbO	Protection Coefficient (Per Cent) for—			
			90 kv.		150 kv.	
			Experimental	Calculated	Experimental	Calculated
		%				
F-1	Commercial x-ray	46.1	15.0	15.0	15.1	15.0
F-3	Optical flint	46.0	15.1	14.9	15.0	14.9
F-4	"	51.5	17.8	18.0	17.6	18.0
F-5	Commercial x-ray	60.3	22.3	22.8	22.3	22.8
F-9	"	65.0	23.9	25.4	24.0	25.4
F-12	Optical flint	69.8	28.4	28.1	28.6	28.1

TABLE V.—EXPERIMENTAL VALUE OF PROTECTION COEFFICIENT OF BARIUM-FLINT GLASSES COMPARED WITH VALUES CALCULATED BY MEANS OF EQUATIONS 13 AND 14

Glass	PbO	BaO	Protection Coefficient (Per Cent) for—			
			90 kv.		150 kv.	
			Experimental	Calculated	Experimental	Calculated
	%	%				
BF-1[a]	6.87	29.15	....	15.7	....	11.4
BF-2[a]	23.5	14.5	15.3	14.2	13.6	12.0
BF-3[a]	44.1	<.1	14.8	15.1	14.7	14.9
BF-5	47.1	14.35	26.4	27.2	24.6	25.0
BF-7	45.38	15.02	26.6	26.7	24.7	24.4
BF-9	60.0	<.1	23.4	24.0	23.5	23.7
BF-12	52.0	13.94	29.4	29.6	27.7	27.4
BF-14	53.15	13.01	30.0	29.6	27.7	27.5
BF-15	52.6	14.7	29.9	30.5	28.2	28.2
BF-17	51.2	15.50	29.7	30.3	28.0	27.9
BF-18	62.6	2.34	27.0	27.0	26.5	26.5
BF-20	61.6	2.52	27.0	26.6	27.0	26.0
BF-22	60.9	6.5	28.3	29.1	28.0	28.0
BF-24	62.1	5.3	28.4	28.9	28.0	28.0
BF-26	61.24	5.50	28.7	28.0	28.1	27.6
BF-27[b]	52.6	14.6	31.0	30.4	28.8	28.1
BF-28[c]	62.0	5.3	30.5	28.8	29.6	27.9
BF-29	62.0	8.0	31.4	30.2	30.1	29.5
BF-30	62.0	10.0	33.4	32.3	31.7	30.7
BF-31	61.0	9.7	....	....	30.6	29.9

[a] Equations 13 and 14 do not strictly apply here since the percentage of lead oxide (PbO) in these glasses is less than 46 per cent.

[b] Glass BF-27 is an experimental x-ray glass containing 5 per cent of TiO_2.

[c] Glass BF-28 is an experimental x-ray glass containing 2 per cent of UO_3.

Further study of the relation between this increase in protection coefficient with the BaO component of the glass reveals that for radiation of a given quality, the amount by which the coefficient is increased is approximately a linear function of the BaO component and, as is to be expected, is essentially independent of the PbO component. In Figure 8 the amount by which the protection coefficient of a barium-flint glass exceeds that of a flint glass containing the same percentage of PbO, has been plotted as a function of the BaO component of the barium-flint for three different tube voltages, 90, 150, and 195 kv. The points of Figure 8 show considerable scattering arising from the extent to which components other than PbO and BaO contribute appreciably to the total protection coefficient of the glass. However, for x-ray barium flints this scattering is no greater than 3 per cent of the total protection coefficient of the glass. One exception is to be noted, an "experimental" x-ray glass containing 2 per cent of UO_3 (uranium trioxide); in this case the heavy oxide had been included in order to test the effect of heavy oxides other than those of lead and barium. From the data plotted in Figure 8, the following relations have been obtained:

$$\text{For } 90 \text{ kv.: } C_{BaO} = 0.727P_{BaO} + 1.2 \qquad (11)$$

$$\text{For } 150 \text{ kv.: } C_{BaO} = 0.586P_{BaO} + 1.0 \qquad (12)$$

$$\text{Where } 0 < P_{BaO} < 15$$

where P_{BaO} is the percentage of barium oxide in the barium flint, and C_{BaO} is the amount by which the protection coefficient of a barium flint exceeds that of a flint containing the same percentage of lead oxide.

2. *Protection Coefficient and Chemical Composition*

By adding Equations 10 and 11 an expression is obtained for the protection coefficient of a barium-flint glass for 90-kv. x-rays in terms of the barium-oxide and lead-oxide components of the glass.

$$C = 0.553P_{PbO} + 0.727P_{BaO} - 9.3 \qquad (13)$$

$$\text{Where } \begin{cases} 46 < P_{PbO} < 70 \\ 0 < P_{BaO} < 15 \end{cases}$$

The corresponding equation for 150-kv. x-rays is obtained by the addition of Equations 10 and 12;

$$C = 0.553 + 0.586P_{BaO} - 9.5 \qquad (14)$$

$$\text{Where } \begin{cases} 46 < P_{PbO} < 70 \\ 0 < P_{BaO} < 15 \end{cases}$$

Equations 13 and 14 are based on observations of flint glasses approximately 6 mm. thick. Kaye[19] has reported that for radiation of a given quality the lead equivalent of barium-sulphate plaster is not strictly proportional to the thickness of the material. He found that the departure from the linear relationship between lead equivalent and thickness increases with the x-ray voltage and is quite marked for 200-kv. x-rays. Equations 13 and 14 have been tested for glasses up to 10.0 mm. in thickness and have been found satisfactory. However, it should not be assumed that these equations are valid for glasses varying very much from the thickness for which they were derived.

In Table V, the experimentally determined protection coefficients for 90- and 150-kv. x-rays of all barium-flint glasses studied are compared with the coefficients calculated by means of the empirical Equations 13 and 14.

The writer acknowledges the co-operation, assistance, and advice of Lauriston S. Taylor, under whose supervision this work was done.

[19] G. W. C. Kaye, Roentgenology, p. 93. Paul B. Hoeber, Inc., New York, 1929.

ESOPHAGEAL-GASTRIC CARCINOMA SUCCESSFULLY TREATED BY PROTRACTED FRACTIONAL X-RAY

(SIX-YEAR SURVIVAL)

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INTRODUCTION

CARCINOMA of the esophagus constitutes from 2 to 5 per cent of all cases of malignant disease.

It has been shown statistically (Hoffman) that cancer of the esophagus is far from being a rare disease. At the present time it is responsible for over two thousand deaths per annum. The death rate from this disease has increased from 1.0 per hundred thousand in 1915, to 1.7, in 1932, in the United States Registration Area. The rate for males is much higher than that for females. In England and Wales, in 1931, it was 9.09 per hundred thousand for men and 2.99 for women.

Of 37 cases of esophageal cancer seen from 1929 to 1935, 27 were males and 10 females. Its greatest incidence occurs between the ages of 50 and 60 years.

ANATOMIC LOCATION

The most frequent site of predilection is the thoracic portion of the esophagus, then the cardiac, and the least frequent is the cervical portion.

PATHOLOGIC TYPES

There are several pathologic types: (1) The bulky, polypoid tumors which extend into the lumen of the esophagus causing early obstructive symptoms; (2) The shallow ulcerating type, causing early symptoms of mediastinal involvement with clinical signs of pain and backache, although metastases and obstructive symptoms may be absent; (3) The infiltrating scirrhous type which invades the esophageal wall, encircling the lumen, and producing fixation of the walls with marked obstruction.

DIAGNOSTIC METHODS

Radiologic examination with the aid of the opaque barium mixtures will show the site of the growth, its extent, and degree of obstruction. It will at the same time exclude other conditions simulating carcinoma.

Fig. 1. There is marked dilatation of the lower end of the esophagus, just above the diaphragm. Beyond is a carcinoma of the esophagus and cardiac end of the stomach.

Esophagoscopy will reveal the pathologic type of growth, and the anatomic location of the tumor. The instrumental examination gives the opportunity to investigate the amount of patency of the lumen and opportunity for removal of a portion of the growth for histologic examination.

The most frequent histologic structure is that of epidermoid carcinoma, acanthoma. Hornification or pearl formation is not common. Broders finds the majority of the tumors to fall into Grade III and IV, which would make them fairly radiosensitive.

Fig. 2.

Fig. 3.

Figs. 2 and 3. Same patient. Radiographic examination of the esophagus and stomach shows no evidence of obstruction in any portion of the esophagus. There is at present no irregularity in contour such as might suggest the presence of a neoplasm at the cardiac end of the esophagus or stomach.

SURGERY

Achievements of radical surgery in carcinoma of the esophagus are reported by Torek and Eggers, in the United States, and more recently by Tudor Edwards and G. Grey Turner, in England. However, the technical difficulties of the operation are so great, the disease so well established when first diagnosed, and the condition of the patient so poor, that only in exceptional cases can any kind of success be hoped for. However, palliative surgery, gastrostomy in selected cases, is often indicated for the relief of obstruction and for feeding purposes to stave off starvation. The rest given to the esophagus often relieves the pain due to the associated inflammatory congestion.

TREATMENT BY RADIATION

Reports of the complete regression of histologically proven epidermoid carcinoma of the esophagus by radiation methods have been reported in the literature. Guisez, using radium in tube or bougie form and inserting it into the lumen of the esophagus, has reported good palliative results in a large series of cases. By this method he was able to obtain freedom from symptoms in some cases for 11, 10, and 5 years. Holfelder had the opportunity to do postmortem examination of a 65-year-old patient with epidermoid carcinoma of the esophagus, who died five months after protracted roentgen therapy of bronchopneumonia. The esophagus was completely healed, with smooth walls, a linear scar

Fig. 4.

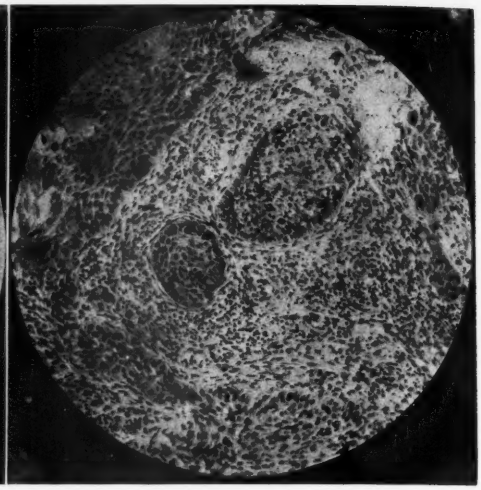

Fig. 5.

Fig. 4. Photomicrograph × 100. Biopsy from esophageal tumor through bronchoscope. *Squamous-cell carcinoma.* There are many tumor cells with very large nuclei. The stroma of the carcinoma is partly edematous. Parts of the tumor are infiltrated with leukocytes and lymphocytes.
Fig. 5. Photomicrograph × 200, from same case.

marking the site of the former neoplasm. Histologic examination of the wall of the esophagus in the region of the scar failed to reveal tumor cells.

High voltage x-rays administered through several portals, giving good palliative results in six cases, has recently been reported by Levitt.

The question as to the best plan of treatment in carcinoma of the esophagus cannot be answered in the light of present knowledge and experience. Whether surgery, x-rays, radium, or a combination of surgery and some form of radiation is to be the method of choice is a question to be determined in the future, as lasting clinical results accumulate.

It is in an endeavor to improve the outlook in cases of esophageal cancer that I thought it of value to report the following interesting case.

Case Record.—Male, aged 53 years, when first seen in March, 1929, complained of difficulty in swallowing and substernal pain of about one year's duration. About a year previously, the patient had had a hemorrhage from his stomach, vomiting a large amount of blood. Thereafter, because he began to notice progressive difficulty in swallowing, particularly solid foods, he was on a fluid diet. The patient lost about ten pounds in the last three months, with considerable loss of strength. He had never been seriously ill before. There is no family history of cancer.

The physical examination showed evidence of loss of flesh and moderate pallor and weakness. He was able to walk about, but was weak and appeared to be chronically ill. The teeth were in very poor condition, showing pyorrhea and caries. The chest was barrel-shaped and hyperresonant. There were no palpable abdominal masses.

Roentgen examination of the gastro-intestinal tract showed a marked dilatation of the lower end of the esophagus, and distal to this a tumor mass involving the esophagus and cardiac portion of the stomach. There were no pulmonary metastases.

Esophagoscopy under local anesthesia, using 10 per cent cocain and adrenalin solution, showed spasticity of the upper portion of the esophagus, which yielded only after prolonged pressure. The mucous membrane was normal up to the junction

of the middle and lower third. Beyond this the mucous membrane was found infiltrated and thrown into folds; slightly beyond this was found a tumor mass, arising from the anterior wall of the esophagus, which partially occluded the esophageal lumen. A piece of tissue was removed for microscopic study. The tumor was quite vascular and a free flow of blood followed the removal of the biopsy specimen.

The microscopic findings of the small fragments removed (Path. No. 17,395) revealed a squamous-cell carcinoma with hornification. The stroma was edematous and there was secondary infiltration of leukocytes and lymphocytes.

Other laboratory findings were as follows: urine, essentially negative; blood, red blood cells, 3,800,000, hemoglobin, 62 per cent, white blood cells, 15,500; polymorphonuclears, 72 per cent, mononuclears, 28 per cent; Wassermann, negative; blood chemistry, glucose, 125 mgm., non-protein-nitrogen, 40.

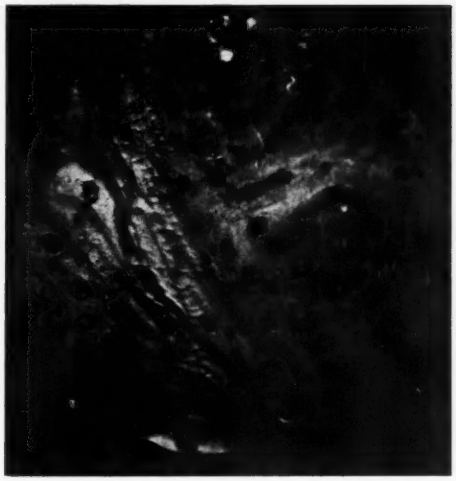

Fig. 6. Photomicrograph × 300, from same case.

TREATMENT

High voltage x-ray therapy, the protracted fractional method, was immediately instituted following the establishment of a definite diagnosis of squamous-cell carcinoma. It was felt that a gastrostomy was not indicated as the patient was able to take liquid nourishment and retain it.

The technical factors were 200 kv., 4 ma., 70 cm. distance. Filtration was through 2 mm. Cu and 1 mm. Al. Large portals averaged 400 sq. cm. Daily treatments were given. Cross-firing of the lower esophagus and cardiac end of the stomach was done through upper abdominal and right and left oblique portals, each portal receiving about 5,000 r units. Forty-two treatments were given over a period of 69 days, the average dose per treatment being 480 r units. Each portal was given the maximum skin toleration until a radio-epidermitis resulted.

Early in the course of treatment, which was effective from the beginning, the patient began to show improvement in swallowing. After a month of treatment he was able to take solid food. The localized pain had diminished; the patient felt generally better and showed a tendency to gain weight. Soon after the completion of the treatment the patient was able to take all solid foods. He had no substernal pain or pain when swallowing The radiographic examination at that time showed only a slight degree of irregularity at the cardiac end of the esophagus, corresponding to the site of the original lesion.

The patient has been seen and examined in the follow-up clinic for the last six years. When seen on March 29, 1936, his weight was 170 pounds, a gain of 26 pounds since treatment. Blood examination showed: red blood cells, 5,000,000, hemoglobin, 80 per cent, white blood cells, 5,000. The patient has been carrying on his usual occupation for the last four years, and is able to eat everything with no pain. The fluoroscopic and radiographic examinations show no evidence of obstruction in any portion of the esophagus.

RÉSUMÉ

The possible reason for success in the treatment of our case may be due to limited localized involvement, the relative radiosensitivity of the growth, and the

fractioning of the dose and prolongation of the treatment.

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A CASE OF BILATERAL OSTEOCHONDRITIS DEFORMANS JUVENILIS COXAE

(LEGG-CALVÉ-PERTHES DISEASE)

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WHILE oftenest associated with Perthes' name, this rare affection of the hip joint was originally reported by Legg (1) in America in June, 1909, although his first published contribution to the subject did not appear until February of the following year. In July, 1910, Calvé (2), in France, evidently unaware of the work of Legg, described under the title of pseudo-coxalgia a series of cases almost identical with those reported by the latter. Finally, in October, 1910, Perthes (3) published in Germany still another series of cases, apparently identical also with those adduced by Legg and Calvé earlier in the same year. Perthes entitled the disease described by him *arthritis deformans juvenilis*. However, he was subsequently obliged to alter the title, because of his inability to discover any evidence of inflammation of a portion of synovial membrane and head of the femur removed by him, rechristening the disease, in 1913, *osteochondritis deformans juvenilis* (4), the principal changes having later been found by him in the subchondrial bone in the head of the femur. In 1916, Legg (5) entitled the disease first described by him *osteochondral trophopathy of the hip joint.* Calvé (6) in his turn proposed in 1921 the substitution of the designation *coxa plana* for the less accurate title ultimately suggested by Perthes, believing it briefer and more truly descriptive of the character of the malady. From the foregoing history it is clear that to Legg belongs the credit for the discovery of the disease, and his name, therefore, most appropriately appears first in the eponymic triad in the subtitle of our article.

The affection under consideration may be defined as an acquired articular malformation characterized by flattening of the superior femoral epiphyses and regeneration of the epiphyseal osseous nucleus, the articular contacts occurring in a defective manner and occasioning, under the influence of fatigue or suddenly accelerated growth, the development of painful symptoms similar to those experienced in all articular malformations.

The consensus of opinion is that the usual age of onset lies between three and twelve years, although the disease is occasionally encountered in adults. It occurs on an average of from two to four times more frequently in males than in females. While both hips are apparently equally liable, the unilateral is by far more common than the bilateral type. Thus, among 38 cases collected from the literature by Perthes (3) in 1910, there were 12 cases of bilateral affection in five males and seven females, ranging in age from seven to 30 years. Of 55 cases observed personally by Legg (5), seven were of the bilateral type. In 1919 Watkins (7) demonstrated a case of the latter form in a boy of five. Sundt (8), in 1920, reported his observations of seven cases of bilateral involvement (among a total of 75 cases studied by him), four of them in boys, the sex of the other three patients not being specified. In 1922, Platt (9) reported a series of 23 cases, twelve in males and eleven in females, two of them being bilateral, one in a boy of nine, the other in a girl of eight. Chruscz (10), in 1925, described a case of bilateral Perthes disease associated with clubfoot in a five-year-old girl. Wassink (11), in 1927, contributed a case of bilateral disease in a female patient of unstated age. In 1929, Kaiser (12) reported the occurrence of an apparently hereditary form of bilateral osteochondritis deformans coxæ in several members of the same family. More recently, in 1931, Orth (13) described a case of bilateral Perthes disease, unsuspected and revealed by trauma, in a man 47 years of age. It is believed that no additional

cases of the bilateral type have since been recorded in the literature.

The etiology of the affection has been continually in dispute. Various and sundry theories have been formulated and advanced in an endeavor to account for its origin. Chief among the more tenable of these are:

(1) The *traumatic theory*, propounded by Legg (1), according to which the disease is the result of vascular imbalance between the head and the neck of the femur, in consequence of slight trauma to the part, a hypothesis supported by the history of trauma in the majority of cases.

(2) The *developmental theory*, adduced by Calot (14), who believes that there is involved a condition of arrested development of the hip joint, marked by an imperfectly formed and shallow acetabulum and a small, malformed head, with a tendency to congenital dislocation of the hip, the result being that the head fits imperfectly into the acetabulum, with consequent osteochondritis from the mechanical disability. In this connection, Jansen (15) proposed a theory to the effect that, in subjects who develop pseudo-coxalgia, the curve of the acetabulum is flatter than the curve of the femoral head, this being caused either by excessive thickness of the bony floor of the acetabulum, or by inward deflection of the ischium in the direction of the mid-line (ischium varum). He asserts that these abnormalities are produced by a small amniotic sac, which either tends to flex and adduct the hip joint and lever the head out of the acetabulum, thus lessening the normal pressure of the head against the acetabulum, or by being drawn tightly over the buttock, bends the ischium inwards.

(3) The *infective theory*, whose numerous supporters (among them Platt (9), its ablest advocate) declare that the condition is frequently associated with pyrexia, enlarged tonsils, or chronic ear disease, the defenders of the theory holding the view that the disease is hematogenous in origin like osteomyelitis, and pointing out the clinical resemblance of pseudo-coxalgia in its active stage to infective arthritis.

Theories of congenital abnormalities of ossification, rickets, syphilis, and variations in activity of endocrine glands have been advanced in turn by their respective proponents and rejected because they were found to be based upon unsound evidence.

In many instances the clinical symptoms and signs of the disease are so indefinite that it is unrecognizable in its early stages. The most common symptom during onset is a limp, which is painless and frequently intermittent, or a tendency to drag the affected limb, with, usually, a slight degree of muscle-spasm, the possible amount of movement in the joint depending largely on the extent of the latter. There may be slight or well marked muscular atrophy. Pyrexia is sometimes noted. During the active stage, which varies in length from about six to eighteen months, there are gradual disappearance of the limp (the latter, however, at times recurring sporadically for brief periods and occasionally continuing indefinitely), spontaneous disappearance of spasm, and, invariably, limitation of range of abduction and internal rotation and, less commonly, of flexion, this physical sign being often conspicuous. The restriction depends upon a combination of factors, namely, localized spasm of the adductor group of muscles, true shortening of adductors, and, in the later stages, the actual mechanical changes in the joint resulting from the deformation of the head of the femur. Prominence of the trochanter on the affected side is a cardinal sign. Shortening of the limb is rare, but, if present, is barely appreciable. The third stage of apparent recovery, with preservation of function in the hip joint, is characterized by the persistence throughout life of trochanteric thickening and a limitation of the range of abduction. Accordingly, while recognition of the affection is mainly dependent on radiography, a tentative clinical diagnosis is warranted in presence of the typical picture of symptoms of recent origin usually referred to one hip, *i.e.*, a hip joint completely fixed by spasm in the position of adduction; undue prominence and palpable thickening of the trochanter, and complete

absence of local tenderness, swelling, or muscular atrophy.

Although it is extremely difficult in frequent instances to distinguish the condition clinically from epiphyseal coxa vara, tuberculosis, and other diseases, inasmuch as the radiographic appearances precede the clinical signs, the diagnosis can generally be made by roentgen rays. The radiographic changes peculiar to the disease consist briefly in the development of a distortion of the head of the femur, which apparently becomes flattened out, and in a broadening and stunting of the femoral neck. At first an increase in the density and a diminution in the size of the bony nucleus causes the head of the bone to appear flattened, the size of the epiphyses remaining unchanged, but the joint interval appearing larger, since less space is occupied by the bony shadow. The bony nucleus next begins to show irregular calcification, some parts revealing increased density, while others undergo rarefaction which continues until the bony nucleus appears fragmented (that is, broken up into areas wherein lime salts are considerably increased in amount, with intervals of diminished calcification between them). The cartilage, deprived of its bony support, and beginning to give way, loses its spherical shape and spreads out laterally. The deformed cartilaginous envelope surrounds the circumference of the acetabulum, and when the bony nucleus reforms, its shape is limited by the boundaries of its cartilaginous envelope. The fragments begin to coalesce, and the density of the entire epiphysis thereupon gradually diminishes until it becomes uniform and equal to that of the opposite side, eventually increasing in size until it practically fills its flattened, cartilaginous envelope.

Fig. 1. Case 1.

The reformed femoral head undergoes molding which persists throughout life, resulting in one of two types of head, namely, globular-round or oval.

The contour of the neck of the femur alters, its upper part becoming broader and its upper angle rounding off, until subsequently there is a shortening of the entire neck, producing an apparent coxa vara. In the beginning of this stage, an ill-defined zone of change in calcification produces a sponge-like area in the upper part of the neck, this metaphyseal change being early and constant. Later on, a regular pattern-like appearance is occasionally remarked, with zones of increased calcification arranged as pockets opening toward the epiphyseal line, each enclosing a corresponding area of rarefaction. This phenomenon is associated with fragmentation and disappears during healing.

There is some question as to changes in the acetabulum, certain authors being inclined to regard these as relatively unimportant, even if actually existent. Thus, Perthes (3) asserts that the acetabulum shows changes only in advanced stages, while Sundt (8) considers that the acetabulum is normal in the late stages of the disease. Platt (9), on the other hand, believes that changes visible at every stage should be regarded in part as the adaptation of the cavity to the altered lines of pressure through the deformed head, and partly as of the same nature as the transformation which the epiphyseal nucleus undergoes, and hence truly specific.

While spontaneous recovery without complete disability is the rule, there is considerable difference in the final results, particularly as regards function of the limb and comfort of the patient. Legg agrees with a number of other observers in the opinion that treatment has no effect upon the condition. However, it is generally believed that if treatment be instituted before the cartilaginous envelope of the epiphysis has become deformed, the subsequent malformation will be much less marked, although fragmentation and cyclical osseous changes will not be entirely obviated thereby. The treatment most widely prescribed consists of fixation in an abducted position, the required duration of fixation being carefully controlled by repeated roentgen-ray examinations to determine the degree of recalcification attained by the head of the bone. In acute cases with a considerable degree of spasm and pain, fixation is sometimes insufficient for relief of the latter, and some form of extension apparatus may be required to overcome muscular spasm. Operative intervention is regarded as unwarranted by the majority of surgeons. However, in cases which subsequently exhibit roentgen-ray evidence of osteo-arthritis, operation for the purpose of remodeling the head of the femur may be advisable.

In view of the comparative rarity of the bilateral form of the affection, it is felt that the following history of a case from our own practice will not be devoid of interest.

A white, female child five years of age, when first seen on Aug. 30, 1932, complained of pain in her left leg. The patient was a first baby, delivered by instruments, her weight at birth having been eight pounds four ounces. Her father and mother had always enjoyed excellent health. The child was never breast-fed, but was put on a modified cows' milk formula. She had suffered from no contagious diseases save an attack suggestive of diphtheria in April, 1932.

Five months prior to consultation with us, the patient began to complain of stiffness in the left limb on arising, and, except in the morning, limped without pain during the day. When her attention was called to her limp, she would stop it. She was taken to a physician, who ordered more rest. Following this advice, the child was kept quiet for two weeks, during which time the limp disappeared, but recurred six weeks later, whereupon the patient was referred to us.

Physical examination revealed a fairly well developed, well nourished female child, with clear, tanned skin, and hair normal in amount and of good texture. There was no undue glandular enlargement. Pos-

ture was good, but the patient limped on the left leg when walking. Thoracic and abdominal organs were normal. Genitalia were normal. Knee reflexes were present and equal. There was no limitation of motion or pain on manipulation of the lower extremities, particularly the left. There was no shortening. The ears were negative. The nose contained a slight amount of discharge, particularly on the left side. The teeth were small and well formed. Buccal mucosa was normal in color. The throat revealed evidence of a previous tonsillectomy, but there was a tiny tab of tonsillar tissue in the right tonsillar fossa.

Tentative diagnoses of tuberculosis of the hip joint, tuberculosis of the spine, and subacute epiphysitis were considered in turn. A tuberculin test was made (right forearm) and an x-ray examination of spine and hips was ordered. After 24 hours the site of the tuberculin test was inflamed, indurated, and elevated, the area measuring 2.5 by 3 centimeters.

Radiographic examination of the lumbar spine, pelvis, and hip joints showed the lumbar spine and pelvis within normal limits. The hip joints exhibited some slight irregularity of the articulating surface of the acetabulum, with fragmentation of the epiphyses of the heads of both femurs. There were small areas of destruction and proliferation of bone on the diaphyseal side of both epiphyses, with slight broadening of the neck of each femur, especially the right.

Accordingly, a roentgen-ray diagnosis of bilateral osteochondritis deformans juvenilis coxae (Perthes disease of both hip joints) was established.

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THE EFFECT OF THE X-RAY UPON THE FINE STRUCTURE OF THE PARENCHYMA OF THE THYROID GLAND

(FIRST ARTICLE)

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INTRODUCTION

SINCE the investigations of Williams (1901), who first introduced the x-ray as an important therapeutic factor in the treatment of thyroid gland diseases, this method has taken a definite place among all the other methods of treatment of Basedow's disease.

We have a large number of clinical articles which mention the beneficial effect of the x-ray for the treatment of the mentioned ailment, though some of their authors point out the possibility of an increase of thyrotoxicosis (Gilmer, Kienböck) during the period of radiation and directly thereafter, as well as the possibility of the subsequent development of a myxedema (Cordua). Surgeons also stress the increased difficulty of future surgical interference because of the thickening of the thyroid capsula and adhesions with surrounding tissue after the use of roentgen therapy. We shall not discuss here the merits or faults of x-ray treatment for hyperthyroidism, but we do wish to point out that the foreign literature particularly, while based upon much clinical data, and while crediting x-ray therapy with much success in treatment of basedowism, is still lacking in exact experimental information upon that question and the experimental data we possess are insufficient.

Most investigators treat the question of decreased gland secretion in a purely theoretical way. Beck speaks of endarteritis obliterans which might be followed by atrophy of the parenchyma, but Professor Nemenow tells of a neutralization of poisonous substances. What do we find in the meager experimental morphological literature which we have on the action of the x-rays upon the thyroid gland? We should say that the results of the investigations, as given by the authors, are very contradictory. Krause, Ziegler, Pfeiffer, Rave, Fiorentini and Louraschi found no changes in the radiated glands of animals. Coulaud's data showed that the normal thyroid glands of rabbits are extremely resistant to the x-ray, and that very strong doses—from 50 to 100 H.E.D.—are required in order to produce a very insignificant decrease of secretion of the organ. But Zimmern and Battez, by radiating the region of the thyroid gland of rabbits, produced a cachexia resulting in the death of the subjects. The histologic investigation of the radiated organ showed its complete atrophy, together with the atrophy of parathyroid glands. This destructive action of x-rays upon thyroid glands is set forth in the investigations of Redaelli and Coulaud. Redaelli showed that the thyroid glands of rats which had been submitted to x-ray action at first show hyperemia of the organ and fading of the color of nuclei in the epithelium, then hydropic degeneration of cells and finally necrosis, accompanied by considerable inflammation in the gland and a fibrinous exudation and the emigration of leukocytes. The colloid became diluted and greatly vacuolated. Coulaud states that strong radiation provokes the degeneration of epithelium, and the nuclei in the cells of the organ change in size, are badly stained, and finally disintegrate.

Examination of human thyroid glands treated by x-rays seemingly shows that x-rays are greatly destructive. Murray observed the diffuse growth of the intra-alveolar connective tissue which could be a result of the atrophy of the parenchyma. Brehm found a sclerosed inflammation of the organ. Wagelin in one case of *struma diffusa et nodosa colloides*, observed after

x-ray treatment, the thickening of layers of connective tissue in the gland and the infiltration of these layers with lymphocytes without apparent change in the epithelium.

Reports of observations of Walters, Anson, and Ivy, who treated the thyroid glands of dogs, showed hyperplasia. They also noticed considerable radioresistance on the part of normal thyroid glands of dogs.

The foregoing shows that the experimental literature gives no exact data of the effect of x-rays upon the thyroid, and that the work of the investigators is contradictory in its conclusions. Some of them (Krause, Ziegler, Pfeiffer, Rave, Fiorentini and Louraschi) maintain that x-rays produce almost no effect upon the parenchyma of the thyroid. As we have mentioned above, the others (Zimmern, Battez, Redaelli, Coulaud) point out the somewhat destructive effect, and some authors (Walters, Anson, Ivy) even speak of the irritative action of radiation upon the cells of the thyroid which results in their hypertrophy and hyperplasia.

The question of which we are treating is of enormous practical importance and, therefore, is worthy of the most careful attention. On this basis we made a series of experiments on the thyroids of rabbits, of which the following is the record of our histological examination.

EXPERIMENTS AND METHODS

For the experiment we took 20 male rabbits, aged from six to eight months. Fifteen were treated with x-rays, five being used as controls. The usual rules for x-ray treatment were followed. The equipment used was: Koch and Sterzel's apparatus and the Coolidge tube. The distance, 24 cm.; filter, 3 mm. Al; voltage, 140 kv.; 3 ma.; dose, 550 r. (The dose was measured with Wolf's iontoquantimeter as well as by the calorimetric method with tablets using the Holzknecht scale.)

The first lot of rabbits were radiated three times, the second lot five times, and the third lot, 10 times; the dose—550 r—was given once per day.

In order to study how time affected the development of the morphologic processes, rabbits were killed at 24 hours, six days, 12 days, 20 days, or 40 days after the treatment. For comparison, a control rabbit also was killed. The specimens of thyroid of both the treated and control animals were fixed with a Zenker formal with the addition of acetic acid (Miloslavsky's method) and then were passed through a series of alcohol baths of which the strength of the alcohol was in an increasing ratio. They were then embedded in paraffin in the usual way. Sections of from five to six microns in thickness were stained with hematoxilin-eosine.

The preparations made by this method served for general survey of the gland conditions, but for fine cytologic examination the specimens were prepared by the Shampy method with a subsequent chromicizing, the paraffin sections being from two to three microns in thickness. After removing the paraffin by treating the sections with H_2O_2, we stained them for chondrioma, using Kull's method.

OUR INVESTIGATIONS

We are presenting the description of the thyroid gland of the control rabbit before giving the histologic findings procured by the examination of the thyroids of the treated rabbits.

Even with little magnification, when making preparation (Zenker—formal) fixation with the addition of acetic acid (Miloslavsky's method, and hematoxilin-eosine staining of a section) one may see that the organ is composed of follicles of varying size. The diameter of glandular vesicles varies considerably, but their main mass is composed of medium- and small-sized follicles: large-sized follicles are comparatively few. The epithelium of the follicles is of a cuboidal or of a low columnar shape; nuclei in its cells are sappy, light-colored, and round, with a chromatic net lying rather loosely. Lum-

ina of the glandular vesicles are evenly filled with homogeneous colloid. Among such follicles, though rather rarely, we found vesicles very much dilated by colloid. The epithelium of these follicles looks as though it had been flattened and the nuclei in the cells of this epithelium are flattened. In consequence of the chromatin being very compact in the nuclei they are deeply stained with hematoxilin. The cuboidal epithelium of the main mass of follicles has sometimes, though extremely rarely, the typical cells with darker stained nuclei.

We see that the large round nuclei, which are light bluish in color when the sections have been stained by Kull's method (fixation by Shampy), usually are disposed at the basal pole of the cells in their middle third. Chondrioma is represented by the finest little sticks which are sometimes gathered in a chain-like arrangement (mytochondria). Usually chondrioma is more or less disseminated around the nucleus in the protoplasm of a cell, but as a rule it is gathered at the apical pole of a cell turned inside to the lumen of a follicle. Here the chondrioma is placed so thickly that microscopically this pole of a cell looks as though it were thickly dotted.

In general, one may say that the chondrioma of a rabbit's normal thyroid gland appears as an elegant piece of openwork. Colloid in the glandular vesicles represents a homogeneous rosy-stained mass, filling evenly the lumina of the follicles. Sometimes individual vacuoles of varying sizes are met along the border of the epithelium. In the individual cell elements, which normally are extremely rare, nuclei are darker. (They take the staining substance more intensively.) In such cells the protoplasm is penetrated with vacuoles and the chondrioma grains, which are larger and rougher than the normal cell grains, lie among vacuoles in loops of a protoplasmic net.

Experiment No. 1.—A male rabbit weighing 2,560 grams was treated five days and received a 550 r dose each day. It was killed 24 hours after the last radiation.

The preparations, when the usual staining method is used, show no difference between the size of the granular follicles in the experimental and the control rabbits. The walls of the follicles present the cuboidal—or low columnar—shaped epithelium, as in the control rabbit, but a closer examination shows that in a number of cells the nuclei are stained considerably darker because of the more compact disposition of chromatin. In the individual follicles we notice that the colloid is vacuolizing at places where it touches the walls of the glandular vesicle. On the preparations made by Kull's method we see that the chondrioma of most of the cells of the epithelium is dainty and more or less evenly distributed in the cell protoplasm. The protoplasm of the cells (darker because their nuclei take the stain better) is penetrated with various sized vacuoles, and chondrioma in the shape of large coarse grains is disposed among vacuoles in the loops of a protoplasmic net. Sometimes the protoplasm in such cells with pycnotic nuclei seems to be separated from them and the nuclei look as though surrounded by light, transparent crowns. Often such cells with dark nuclei and with the vacuolized protoplasm are larger in comparison than the surrounding normal cells. Vacuolized cells are met much more often in the treated than in the control glands.

The homogeneous colloid in a number of glandular vesicles contains various sized vacuoles; but sometimes we find separate small clots, or occasionally a gathering of these clots which, because of the staining, have taken on a bright red color, though the colloid itself has taken a bluish-rosy color. We wish to stress the fact that by the usual technic of making the preparations, we cannot discover these small clots.

It is necessary to mention that in the gland of the treated rabbit the vessels lying in the interstitial connective tissue between the follicles are thickly filled with erythrocytes. No other changes were found by comparison with the control organ.

Experiment No. 2.—A male rabbit, weighing 2,630 grams, was given one dose each day for five days. It was killed seven days after the last radiation. The preparation made by the usual simple method shows that the organ contains small and medium sized follicles. Large follicles were found more rarely in this than in the control rabbit gland. The cells of the epithelium of the follicles are of cuboidal shape and among the cells having the usual light colored, vesicle-shaped nuclei there are already very numerous cells with dark nuclei which seem sometimes to be larger than the neighboring light colored, unchanged nuclei, sometimes finer, sometimes having irregular polyhedral shape. We want to stress that it is impossible to find out with the preparation a law governing the distribution of cells with pycnotic nuclei. Sometimes they gather in a group of cells, sometimes they lie at the periphery of the gland, sometimes in the center separately among the cells which have kept their normal nuclear structure. The Kull method of staining shows us that chondrioma loses its regular distribution in cells of the epithelium. Large chondriomas with coarse appearance are disseminated over a cell and are not more thickly gathered at its apical pole. In numerous cells we observe nuclei stained darker and with a great vacuolization of their protoplasm. The lumina of most follicles are filled with a loose, soft, granular, colloidal mass and in a portion of the glandular vesicles this loose mass fills only a part of the follicles or is disposed in the form of a very fine net. The vessels of the organ are dilated and filled with blood.

Fig. 1. Photomicrograph of chondrioma of a normal thyroid gland.

Fig. 2. Photomicrograph of tissue from the thyroid gland, experiment No. 1, staining for chondrioma. (The same magnification as Figure 1.)

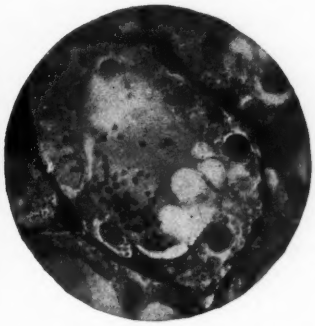

Fig. 3. Photomicrograph of the same thyroid gland as shown in Figure 1 under stronger magnification.

Experiment No. 3.—A male rabbit weighing 2,600 grams was treated with one dose per day for five days. It was killed 14 days after the last radiation. On the preparation we see that the follicles of the gland are medium- and small-sized, that the epithelium of most of the glandular vesicles is of the low columnar shape, and that there is a comparatively small number of cells with pycnotic nuclei.

When using the Kull method for preparing sections it is obvious that, though in some glandular vesicles chondrioma still keeps its coarse appearance and the protoplasm of cells with pycnotic nuclei is penetrated with vacuoles, yet in a series of follicles chondrioma becomes normal and has its regular place in the cell at the apex, where it is collected in the form of a small belt along the border of a follicle.

The colloid which fills the lumina of the follicles is fine, granular, and is rather often penetrated with large vacuoles. Vessels show no particular changes.

Experiment No. 8.—A male rabbit weigh-

ing 2,480 grams was given three doses at one session and killed five days later. The histologic appearance was the same as that observed in Experiment No. 3.

Experiment No. 12.—A male rabbit weighing 2,530 grams was given three doses at one session and killed 40 days after radiation. Preparations made for a general survey by the usual method show almost no difference of the construction of the gland in comparison with a normal gland, except that here and there we see some individual pycnotic nuclei. Preparations made by the Kull method show cells with chondrioma of a soft, fine appearance and follicles filled with a homogeneous colloidal mass. Vacuolization of the protoplasm is observed only in a few cells with pycnotic nuclei. In general we must say that the structure of the gland is nearly normal with the exception of the size of the vessels, the walls of which are thickened, the endothelium proliferated, and the lumen sometimes reduced. In consequence of all these changes we find a thickening of the interfollicular partitions.

In conclusion, we must mention that in several experiments in which the animals were treated with large doses of x-rays (up to 10 H.E.D.), and in those cases in which considerable time elapsed between the last treatment and the killing of the animal, the structure of the thyroid when observed microscopically was nearly normal and it is possible that the only thing of importance was a somewhat higher epithelium in the follicles than in the normal gland.

DISCUSSION OF FOREGOING OBSERVATIONS

Interpreting the foregoing data we see that the technic of the morphologic examination of the organ is a very important factor for revealing the effect of x-ray action upon the thyroid. In our experiments in which the animal was given from three to five H.E.D. and killed 24 hours after the last radiation, the sections prepared by the usual method (Zenker—formal fixation, hematoxilin-eosine staining) showed nothing but pycnosis in some nuclei.

By using the finer cytologic method for making the preparations we obtained quite a different picture. We see here not only the pycnosis in the nuclei, but many structural changes in the cell as well as in the colloid filling the follicles. The cell protoplasm is penetrated by a great number of vacuoles and the chondrioma of the cells under the influence of x-rays is roughened, unevenly distributed in the cell body, and shows the evidence of degeneration. Colloid filling the follicles undergoes a peculiar process of disintegration. First, small, individual, more compact and darkly stained clots appear; second, vacuoles of various shapes and sizes may be seen; third, the homogeneous colloid becomes granular and finally it nearly disappears in many of the follicles. Here it will be interesting to call attention to the manner in which the x-ray acts destructively, according to what we call the "island principle"; that is, the destruction of isolated cells or groups of cells with an accompanying lack of demolition of the parenchyma as a whole.

Bordier presumes that the x-ray changes the colloids of high dispersivity into colloids of a lower dispersivity. The observations of the Academicians Nadson and Rokhlina prove that the homogeneous plasm becomes somewhat foggy one hour after radiation. This change indicates a lowering of its dispersivity. With these apparent changes of the protoplasm, the nucleus itself at first does not show any changes, but soon it also becomes foggy, its fine granular structure becomes coarser, and the contour of its nucleus becomes more distinct. Our observations show that under the x-ray action, first chondrioma suffers degeneration, then the cell protoplasm degenerates, and then comes the pycnosis of the nuclei.

Thus our finding concerning the effect of x-rays upon the cell and its organoids coincide with the observations of Academicians Nadson, Rokhlina, Vail, Frenkel, and Jasvoin. The destruction which is

observed in the colloid may be explained as a change in its dispersivity under the influence of the x-ray.

The degeneration of the cells of the thyroid as well as of its colloid depends upon the amount of radiation. The stronger the dose, the greater the number of affected cells. Here it is necessary to stress the fact that the degeneration of the number of cells was less in the animals which were given the same dosage, but which were killed in the early days after the radiation, than in the animals which where killed five or ten days after the last radiation. This confirms the opinion that x-rays affect a series of cell elements but that the process of degeneration is not simultaneously developed in them. Possibly the reason for this is that some cell elements take the direct action of x-rays, while the other cells get the rays by reflection; or possibly this unequal effect of x-rays is explained by the various functional conditions of the cells in the organ.

The disappearance of colloid in follicles, or the decrease of the colloid, may probably be explained by the fact that the action of x-rays stops for a time the production of colloid, whereas the destroyed colloid is probably quickly eliminated from the organ.

The connective tissue and vessels of the organ treated by x-rays show the thickening of the vascular wall and some proliferation of connective tissue around the large vessels. When much time has elapsed after the radiation we observe the thickening of the partition between the glandular vesicles. Depending upon the dosage, the above-mentioned process in the cells and colloid stops and they return to their normal state in from 20 to 40 days after the radiation. We observe that the return to normal consists of a gradual decrease of the number of cells in the state of necrobiosis, the chondrioma in the cells again returns to its fine granular structure and takes its definite location in the cell bodies. That is, it prefers to gather at the apical poles of the cells. The lumina of the follicles again begin to fill up with the homogeneous colloid. In some experiments in which strong doses of x-rays were given, after the lapse of considerable time and the return of the organ to its normal structure we sometimes observed follicles with more highly and strongly developed epithelium than in the controls—the same findings as those of Walters, Anson, and Ivy. But we do not quite agree with the explanation of these investigators. Their opinion is that the action of x-rays provokes the hypertrophy and hyperplasia of cells in the thyroid. We consider that the x-rays provoke the destruction of a number of cell elements in the organ and that the hypertrophy of the remaining cells is the result of the greater activity that is forced upon them. Thus, the action of x-rays, when a large dose is given, finally produces an effect somewhat similar to thyroidectomy when the phenomena of compensatory hypertrophy are developing in the remainders of the organ (Zimnitsky, Zatvornitskaya, Lozovsky).

On the basis of the present data we came to the following conclusions:

1. The parenchyma of the thyroid is sufficiently resistant to the action of x-rays.

2. The fine cytologic preparation of a thyroid reveals the processes that take place in the cells more fully and more quickly than the usual morbid-anatomic methods and permits the observation of the initial steps of the changes taking place in the cells under the action of x-rays.

3. Changes in the cells of a thyroid under x-rays deal with the protoplasm as well as with the nucleus and chondrioma. In the cell protoplasm there appear vacuoles of various sizes; chondrioma becomes coarse and granular and loses its regular distribution in the cell body; the nucleus of such a cell undergoes pycnosis; and some of the affected cells finally disintegrate.

4. The action of x-rays upon the organ follows the so-called "island principle."

5. In addition to the foregoing changes taking place in the individual cells of the thyroid (the number of these cells de-

pending upon the strength of the radiation of the organ), chondrioma under the action of x-rays in all the cells of the gland undergoes degenerative changes, that is, becomes coarse and granular and loses its regular disposition in the cell body, while the nucleus and the protoplasm of the cell keep their morphologically normal structure.

6. Colloid in the follicles of the irradiated thyroid becomes granular, undergoes vacuolization, and decreases in quantity in the organ.

7. The structure of the thyroid regenerates when a lapse of time is permitted after radiation. (The period of time is in direct proportion to the strength of the radiation.) In the experiments in which we used large doses of x-rays and permitted a period of time to elapse, we sometimes noticed the reconstruction of its normal structure, higher epithelium in follicles, and increase of colloid in the organ. These observations may be explained by the compensatory hypertrophy which develops in the cells of the gland in consequence of the disintegration of a number of cells affected by x-rays.

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CALCIFICATION OF THE BRAIN CORTEX ASSOCIATED WITH HEMANGIOMA OF THE FACE AND MENINGES

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A NUMBER of cases have been described recently in which a hemangiomatous nevus of the face is associated with a calcified intracranial hemangioma. The following two cases are further examples of this affection.

CASE REPORT[1]

Case 1. *History.*—F. D., a boy, aged 8 years, who gave no history of familial disposition. One younger sister is normal. Shortly after birth the parents noted a port-wine nevus on the left half of his face. The mother states that at the age of four months the patient had an attack of high fever with fits, and after that "paralysis of the right side." Since then, he has had several fits daily which last one or two minutes. The child is very active during the day and very restless at night. He does not go to school.

Examination.—The patient is normal in size and development. He weighs 22.3 kg.; length is 121 centimeters. The left side of the face is the seat of a large angioma of the "port wine-stain" type, which extends from the nose over the left side of the forehead; otherwise his skin is normal. His skeleton and internal organs do not show anything abnormal.

Neurologic Examination.—The patient's left pupil is larger than the right, and his right pupil reacts less to light than his left. His right eye is in position of abduction which is maximally increased on convergence. His vision as far as can be tested is r, 5/50; l, 5/15. Eye fundus: nothing abnormal. The patient has facial paralysis on the right side; the other cranial nerves are normal. His right arm shows spastic paresis with increased reflexes. The right arm is 3 cm. shorter than the left. There is no marked atrophy. There is slight motor weakness of the right leg as compared with the left. Knee and ankle jerks are equal on both sides. Sensation is normal, with no ataxia. Speech and intelligence are normal. The child writes his name with his left hand, and is able to count.

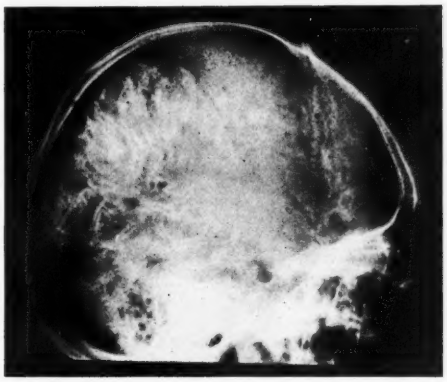

Fig. 1. Lateral view of the skull in Case 1. Films show sinuous shadows in the region anterior to the coronal suture, but more pronounced in the region of the parietal bone and occiput on the left side, which seem to imitate the gyriform appearance of the brain cortex. There are no shadows in the area of the cerebellum. The opacities are strictly localized on one side, showing a very sharp and straight medial border a little to the left of the middle line.

Description of Fits.—At the onset the child yells, falls to the ground, becomes rigid, his face pales, and he is incontinent. The fit lasts for about one minute.

Radiogram.—The skull films (Figs. 1 and 2) show, in the region anterior to the coronal suture but more pronounced in the region of the parietal bone and occiput on the left side, sinuous shadows which seem to imitate the gyriform appearance of the brain cortex. In extent they correspond to convolutions of the frontal, parietal, temporal, and occipital lobes of the cerebrum.

[1] The cases were observed in the x-ray department of the Rudolf Virchow Hospital, Berlin. The first case was sent to the hospital by Dr. B. Bendix, to whom I am indebted for the clinical history.

Fig. 2. Postero-anterior view of the skull in Case 1. (See caption for Figure 1.)

Fig. 3. Lateral view of the skull in Case. 2. Films show enlargement of the left orbit. The left petrous bone seems to be larger than the right. The arcuate eminence stands out more distinctly on the left side than on the right. Small irregular opacities are disseminated over the area of the left frontal, parietal, and occipital bone. Superimposed over the posterior border of the helix are sinuous double contoured lines.

There are no shadows in the area of the cerebellum. The opacities are strictly localized on one side. They show a very sharp and straight medial border a little to the left of the middle line. In cases in which the sinuous shadows correspond to the sulci of the brain, we usually find two lines running parallel for a distance of about one millimeter. But toward the periphery, where the lines seem to correspond to the surface of the gyri, they are single. Anteriorly, in front of the coronal suture, the described arrangement is not as distinct. The skull bones present a certain asymmetry, a small sella, and a nonpneumatized sphenoidal sinus; otherwise, they are normal. Stereoscopic examination does not give further information in regard to localization of the described opacities.

The diagnosis at which we arrived was calcified intracranial hemangioma.

Case 2. *History.*—R. S., a boy, aged 7 years, who gave no history of familial disposition. At birth the mother noticed a nevus occupying the whole left side of the face, as well as a marked enlargement of the left eyeball. Since the age of about six months the child has been unable to see anything with his left eye. Four days before admission to the hospital he had a hemorrhage in his left eye. Further, there is nothing abnormal in the history.

Examination.—Seven-year-old boy of normal size and weight. There is slight hypertrophy of the left half of the chest and the upper extremity. The whole left side of the face is occupied by a nevus vasculosus, which extends over the cheek and forehead and is sharply limited against the middle line. There are small teleangiectatic spots on the right side of the face, and pronounced asymmetry of the whole face.

An examination of his eyes revealed the following: the right is normal; the left shows buphthalmus. There is a hematoma of the anterior chamber, which is filled completely with blood. Examination of the left fundus was not possible. Vision in his right eye is 5/25, and in his left *nil*. Intraocular tension is normal on both sides. Neurologic examination does not reveal

anything abnormal. Skeleton and internal organs; no pathology.

Radiologic Examination.—There is enlargement of the left orbit (Figs. 3 and 4). There is a slight deviation of the septum nasi to the right. The left petrous bone seems to be larger than the right, especially on the films in the Stenvers position, but also on comparison in the postero-anterior view. The arcuate eminence stands out more distinct on the left side than on the right. Postero-anterior and lateral views show small irregular opacities disseminated over the area of the left frontal, parietal, and occipital bones. Super-imposed over the posterior border of the helix are sinuous double contoured lines (as seen in the previous case). All parts of the left hemisphere seem to be involved, although in different degrees.

X-ray Diagnosis.—Multiple intracranial calcification, probably due to calcified intracranial hemangioma.

Fig. 4. Postero-anterior view of the skull in Case 2. (See caption for Figure 3.)

DISCUSSION

In discussing the two cases attention may be directed to a recent paper by Knud H. Krabbe, who has compiled the literature on this subject and has himself observed five cases, one of which he was able to study histologically.

Probably the first one to describe a case of nevus vasculosus combined with hemangioma of the leptomeninges and hemiplegia was S. Kalischer, in 1897 and 1901. The first x-ray films of the same affection were published by Parkes Weber, in 1922 and 1928, and by Dimitri, in 1923. Reference may be made to the excellent monograph on angiomatous tumors of the face by Cushing and Bailey, who discuss the pathology and clinical picture of the disease. The last named authors had never observed any case like the two described in this paper, but mention those described by Dimitri and Marque. Beside the papers listed by Krabbe, Williams, in England, and Dyes, in Germany, have recently published cases which in the x-ray appearances are almost identical with those of Case 1 of this paper.

In their book, Cushing and Bailey point out how these vascular malformations may occur. The association of congenital nevi of the skin with telangiectatic tumors of the meninges and brain can be explained only on an embryologic basis, since originally the circulations in the different layers of the cranium are all derived from the same source.

The question we are most concerned with is: What is the anatomic substrate for the described calcified shadows in the x-ray films?

From the symptoms in our first case we may consider the presence of a tumor involving the motor cortex, which, on the basis of our clinical and pathologic experience, we may diagnose as an hemangioma of the leptomeninges, the dilatation of the vessels presumably localizing in the veins of the pia (Cushing and Bailey). According to these authors no arterial angioma of the brain has been reported in association with a nevus vasculosus of the face. Since we know that calcifications in hemangio-

mas are rather common either in the wall of vessels or as calcified thrombi within the lumen (Dunn, McCallum, Ruggles), we are inclined to think of the opacities in our cases as calcifications localized in the wall or lumen of the vessels. This probably explains the scattered irregular shadows as we find them in our second case.

The sinuous opacities, which are so outstanding in our first case and also visible on one plate in the second case, have been explained in the literature (Parkes Weber, Brushfield and Wyatt, Brinton) as diffuse calcified meningeal hemangiomas, the calcareous deposit localizing in the pia mater which closely follows the brain convolutions. Postmortem findings by Krabbe suggest another explanation. In his case, the x-ray picture of which is almost identical with ours, the pia mater did not contain any calcifications either in the connective tissue or in the vessels, although it was somewhat angiomatous. All the calcifications were localized in the brain cortex which appeared to be scattered with lime salt deposits of different sizes and shapes. The granules were situated for the most part in the superficial layers of the cortex and had no relation to the vessels. In the calcified areas the number of nerve cells was considerably reduced. Krabbe believes that the changes in the brain are not secondary to angiomas of the pia mater. The syndrome should be related to a more generalized malformation of the organism, originating in fetal life, which leads to angiomas of the face and pia as well as to aplasia, sclerosis, and calcification of part of the brain cortex. The x-ray films and postmortem findings in a similar case published by Brushfield and Wyatt, in 1928, though having escaped general attention, are of great interest in the light of the findings by Krabbe. In their case the cerebral cortex showed a general deficiency of neurones. Beside a nevoid condition of the meninges, there were scattered through the portion of the cortex underlying the angioma minute round bodies, varying in size and distinguishable from pigment granules by their refractile center. No real explanation for these structures was advanced; the pathologist considered the possibility of protozoa being present. In view of the findings by Krabbe, we may be justified in assuming that the described structures were granules of lime salts scattered through the surface of the brain.

There are some points in the arrangement of the sinuous shadows which give support to the theory that calcium is not localized in the wall of vessels of the pia mater, but in the brain surface. With Dyes, we can assume that calcifications of the vessel walls would not be in a continuous, uninterrupted line as we see it in our case. The roentgenogram, especially at the periphery of the opacity, gives the impression that the whole area is impregnated with calcium.

Peculiar to all described cases is the preference of calcifications for the posterior parts of the cerebrum, although our first case shows some in the frontal area. The cerebellum seems always to be free of the affection.

Finally we may mention the frequent association of nevus vasculosus of the face with congenital hydrophthalmus, which we find also in our second case, either as an expression of general malformation or as a sign of local angiomatous affection of vessels of the eyeball.

SUMMARY

Two cases, presenting association of extensive nevus of the face with peculiar intracranial calcifications, are reported. The clinical symptoms of hemiplegia in one case suggest the presence of an intracranial hemangioma involving the motor cortex. In view of the micropathologic findings in a similar case, and of the arrangement of the sinuous shadows in the x-ray films, it is assumed that the calcifications are probably localized within the superficial layers of the brain cortex. The second case presents a congenital hydrophthalmus.

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SOME LAWSUITS I HAVE MET AND SOME OF THE LESSONS TO BE LEARNED FROM THEM

(Ninth Installment)

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EXPERT TESTIMONY

SINCE the appearance of the first of this series of articles and experiences in September last, about thirty-five readers have written asking me to discuss the general subject of expert testimony. Therefore, while not strictly in line with the general trend of this series, it approaches so close—and, in fact, does include—some of the lawsuits I have met as well as the lessons to be learned therefrom, that I will try to epitomize the subject in this installment.

It may be interesting to many to know the *origin of expert medical testimony*.

Expert medical testimony originated about the middle of the fourteenth century in England, where, during a trial of a criminal case, the justices before whom the trial was being held were unable to determine to their satisfaction, and from inspection and their knowledge, whether or not a certain injury constituted mayhem. In order that they might have the benefit of an expert's opinions in evidence, they called surgeons from London, "*Ad informand dominum regem et cur.*"[1]

This innovation proved to be so illuminating and cleared the problem so satisfactorily that the experiment was decided to be a pronounced success. Since that original use of expert medical testimony, surgeons, physicians, and more lately specialists in the various branches of medicine, have been called to assist the courts and juries to understand and comprehend medical and surgical technicalities, until at this time medical experts are called upon to give expert testimony more often than all other expert witnesses combined.

Expert testimony has been much discussed both in lay and medical publications, but is such a broad subject that there is always plenty to be said without repetition.

An extremely important matter centers around the limitations of the testimony permitted to be given by an expert witness. It must be evident that upon exactly how a medical expert witness qualifies or has been qualified, depends the scope of the expert testimony he may be expected or allowed to give.

Not infrequently—particularly in the smaller communities—physicians are qualified in general medicine or as all-round medical experts. Consequently, such excessively broad qualifications pave the way for almost any kind of questioning upon medical subjects. However, nearly every medical expert witness prefers to designate what he shall or shall not be qualified as expert on (and he is wholly within his rights in so doing). If the witness knows what is best for him he will insist upon being qualified on his specialty only, unless he desires to be qualified as a general practitioner.

Surgeons, pediatricians, radiologists or any other specialists may be qualified in their own special lines of practice and not be subjected to the embarrassment of questioning upon subjects with which they are not expertly familiar. Since it is well known that every conscientious physician is qualified to answer correctly only a comparatively few questions outside of his own specialty, such limitation of expert qualification carries with it distinct and definite advantages for the medical expert witness who desires to avoid questioning outside of his special expert knowledge.

In a rather celebrated Louisiana case[2] a

[1] Liber Assize (28 Edw. III) 145 Pl. 5.

[2] State *vs.* Scruggs, 116 So. R., 206.

physician who had qualified as a roentgenologist, protested against being examined and questioned on any other subject. Inadvertently, however, later during the course of the trial, he attempted to answer a question relative to certain surgical technic and was very properly prevented from so doing.

During the last forty or fifty years particularly, medical expert testimony has figured prominently in legal actions before courts. While at first this kind of testimony was received by the courts and juries with the respect and deference which honesty, learning, and intelligence deserve, in more recent times, particularly during the last fifteen or twenty years, numerous elements in the methods of procuring and introduction of medical expert testimony have tended to place it in a much lower plane than it formerly occupied in the esteem, confidence, and honored regard of the judiciary, the bar, the press, and the public. Probably the principal reasons for the apparent lowering of the esteem and credit in which expert medical testimony is held lie in the seeming and at times quite evident partisanship of some of the expert witnesses; the employment of physicians to give expert testimony whose qualifications in education, special training, and experience fail to properly fit them for such service; the frequent appearance in court of certain physicians who make a business of testifying and thereby become professional expert witnesses, and last, but by no means least, the impression—given out mostly by certain unscrupulous members of the legal profession—that expert witnesses can be secured who will testify to anything, one way or another, at so much per day.

All these elements, acting conjointly and together, have had a tendency to very materially lower the credibility of the medical expert testimony from its once high pedestal; yet among the better class of attorneys, who are known to handle only cases which have genuine merit and who are careful to employ—or call—only such expert witnesses as have a standing and reputation for probity above doubt or challenge, medical expert testimony still occupies a high rank, is listened to with respect, and is heeded when so introduced. Given such conditions, under usual circumstances this kind of testimony is considered as convincing and worthy of credence as honest, decent, and law-abiding citizens are accustomed to concede to their physicians.

Naturally, it is of utmost importance that those who render expert medical testimony should be actually well qualified so to do. Unfortunately, attorneys—who choose nearly all expert witnesses—are not always able, either from ignorance or other reasons, to secure those who are entirely competent. Often attorneys do not care to pay adequately for the time of those who are in every way competent, and shop around until they find some one who will be "just as good," who will appear for a cut rate. The saying that "everyone loves a bargain" applies here. Also, some mediocre men, who are tempted by the apparently lucrative fees to be earned as expert witnesses, are willing to shade their opinions and even allow their consciences to become elastic, in order to secure the employment and get the fee.

An example of this sort may be related from the experience of the writer in *a spinal injury case.*

In a suit tried before the Superior Court of Cook County, Illinois, in which an estimable young woman of high type had brought action against a railroad company for injuries resulting from an accident to her spine, the plaintiff had had roentgenographic examinations made by me, a few months before her injury, while searching for a suspected renal calculus. Films made of the same region after the accident disclosed definite and certain changes in the spine and the sacro-iliac region. A physician employed by the claim department of the defendant corporation admitted that there was unquestionably some injury shown in the films and informed me that he would recommend settlement of the claim.

The attorneys for the railroad company insisted upon going to trial with the suit. At the trial, the writer appeared as an expert witness, being called in that capacity by the plaintiff. The differences between the two sets of films made before and after the accident were explained, and then the expert witness was (surprisingly) excused without cross-examination. Two other physicians, neither of whom had any standing as roentgenologists, testified that the two sets of films showed identical and normal conditions.

At the request of two of the jurors, the writer was recalled to the witness stand and again asked to explain the differences between the condition found in the two sets of films. My testimony was entirely upon the interpretation of the films as I saw them and showed them to the jury. Evidently my testimony established the claims of the plaintiff, as the jury rendered a verdict for her and fixed the amount of her damages at $11,000, which the railroad company immediately settled for $9,000.

One of the physicians who had testified that the two sets of films showed identical and normal conditions came to me afterward and said that he had listened to what I had said when recalled to the witness stand, and shamefacedly admitted that if he had known there was so much difference, as explained by me, he would not have testified. He admitted that he had not seen the films before examining them while on the witness stand, and that he had not known who had or would interpret them.

This was just one of those instances in which a man was selling his testimony, irrespective of right or wrong, and it is related to illustrate one of the reasons why medical expert testimony is often regarded as unreliable.

When witnesses have been qualified satisfactorily to the court, so as to enable them to give expert testimony, they are generally subjected to direct questioning, as is the custom with ordinary witnesses. In addition to the direct questioning, or what is known as direct examination, they are frequently asked what are known as hypothetical questions.

Hypothetical questions are generally based upon facts relative to the cause on trial which the expert witness has not personally observed. They are usually founded upon facts or evidence which have been introduced in the trial, and contain such portions of the evidence as the attorneys propounding the hypothetical questions desire either to prove or to disprove, and only that portion of the aforementioned evidence which will be helpful and of advantage to a given side of the situation. Consequently, a carefully outlined statement of the facts or evidence is stated to the expert witness and he is usually asked if he has an opinion regarding the same. Of course he has an opinion or he would not be there. He is then (usually) asked, What is that opinion?

Customarily the hypothetical question is so prepared that it may be answered by "yes" or "no," and the expert witness is expected to answer it in that manner. However, it is within the experience of all who have been on the witness stand as expert witnesses, that some hypothetical questions cannot be answered by a simple "yes" or "no." Generally this is due either to faulty questioning or to lack of exact knowledge of the technical subject which comprises the cogent reason for propounding the question. In such instances, the witness, if he knows his strength (in that he knows that he knows more about the subject that the questioning attorney can possibly know), will state that *the question cannot be answered "yes" or "no" without qualification.*

These hypothetical questions are sometimes extremely complicated and intricate in their ramifications, and extremely lengthy. I have sometimes answered such questions that required as long as thirty to forty minutes for the questioning attorney to read. In the second installment of this series, published in October, 1935, will be found a verbatim transcript of one of that type. On page 454, the entire page is oc-

cupied by a question propounded to Dr. Hickey, to which the good Doctor's answer was, "Yes, the question is too indefinite to give an answer." Again, immediately following the foregoing in Dr. Hickey's direct examination (on page 455), an hypothetical question consisting of 427 words was asked, which was answered in 17 words.

Superficially, and without an intimate knowledge of the facts, it may appear that even amply qualified and sincerely honest expert witnesses disagree with each other and apparently flatly contradict each other's testimony. However, speaking from many years of observation from the outside and experience on the inside, I can say with every certainty of being correct, that such differences of opinion and contradictions are only apparent and not at all real. The explanation is very simple and easy of comprehension. It is simply that the seeming contradictions and diametrically opposite opinions among honest witnesses are based upon the manner of asking and the verbal construction of the hypothetical questions. The subject or subjects of the question are presented so differently by the astute word-twisting attorneys for the opposite sides of the suit, that it is usually absolutely impossible to answer them alike and for the answers to agree with each other. Attornies' forensics make more for disagreement of witnesses than do any other thing, and if these same medical expert witnesses were to meet in a consultation room or over a patient, *they would in all likelihood agree entirely and explicitly upon the identical propositions or problems upon which the smooth-tongued attorneys make them appear to disagree when on the witness stand in court.* I know this and have seen it in almost innumerable instances and have been slyly joked about it by friends in the legal profession. I once introduced such a lawyer, a really able trial lawyer, as "my friend, Mr. B., who has probably succeeded in making more physicians lie than any man I knew." He came back at me, as soon as he had a chance, by saying that it was easy to make Dr. Trostler lie—all he need do was to ask him an hypothetical question.

Of course, the attorneys for both sides of a suit use every possible means to bring out the testimony which, in their opinions, will influence the court and jury to decide in favor of their clients and against the other side of the case. Consequently, the statements and testimony of expert and other witnesses are often purposely misunderstood and distorted by the keen, word-twisting paraphrastic forensics. It is this distortion and word-twisting of the attorneys, causing the apparent (but seldom real) contradiction and disagreement, that has called down so much unfavorable criticism and comment upon medical expert testimony, and the tendency to discount its value in determining matters of critical and scientific importance.

As trials are nowadays conducted, it is almost impossible for expert witnesses on opposite sides of any lawsuit to agree. This is, as previously stated, because the witnesses for the two sides are not asked questions nor are they expected to give opinions upon the same assumptions. Attorneys for each side frame and formulate hypothetical questions which differ as night does from day, each omitting all that portion of the evidence or any items which will damage his side of the case, and including every iota of what may or might benefit his side. This is sometimes done to so extreme a degree that—in some instances within my experience—the opinions of the expert witness were rendered entirely worthless and were thrown out by the clear insight of the judge before whom the testimony was given.

The principal difference between ordinary testimony and expert testimony is that the former consists of the recital of facts and actual incidents connected with the cause under investigation, while the latter may be, and usually is, a recital of both facts and opinions by persons who have convinced the court that they have sufficient expert knowledge concerning the particular subject, trade, or profession or other technical matter to enable them to

reach reasonably correct and logical conclusions from facts recited, given, or placed before them. These conclusions are called "opinions," and, when logical and based upon either the testimony of ordinary witnesses or known facts connected with the cause under investigation or trial, constitute expert testimony.

But it must be understood and no mistake made in understanding, that no witness, either ordinary or expert, may reach illogical conclusions and state such as expert testimony.

In other words, common or factual testimony relates to impressions received by the five senses and is, therefore, objective; whereas, opinion or expert testimony consists mainly of the mental reactions and conclusions derived therefrom, as the result of previous sensory impressions based upon experience and knowledge, and is a subjective procedure.

As stated, expert witnesses are permitted in their testimony to give their opinions, because of their superior knowledge. They are qualified (or supposed to be qualified) to be able to formulate correct opinions about the facts involved, wherein ordinary persons are lacking in the special skill or knowledge of the subjects in question.

It is obvious to my readers that many scientific facts are entirely—or perhaps we better say more or less—meaningless to the average person and, as such scientific facts may, and frequently do, have great and important weight and value in the correctness or justice of certain acts, claims, or propositions, it is necessary and proper that such scientific facts be elucidated, explained, or demonstrated by those trained and educated to properly present them to the court, the judge, or the jury.

It has been aptly said: "Expert testimony is admitted because the witnesses are supposed to have knowledge upon the subject of inquiry which jurors generally have not, and are therefore supposed to be more capable of drawing correct conclusions from facts and basing opinions upon them than jurors are generally presumed to be."[3]

"While it may be true, that an expert witness may give reasons for his opinion, he is not required to do so. The facts contained in the hypothetical question propounded to the witness are in themselves reasons for an answer," according to the Appellate Court in California, as expressed in its decision in Thomason *vs.* Hitchcock, 46 P. R. (2nd), 832.

While expert witnesses are not generally or as a rule expected to testify as to facts, as is an ordinary witness, in a considerable number of leading cases the expert's testimony has been a combination of factual and expert knowledge. Thus, in a New Jersey case,[4] a medical expert witness was asked regarding the subjective symptoms which the patient (defendant) complained of, and witness was permitted to answer and then formulate his opinion as an expert relative to the patient's (defendant's) condition from these subjective symptoms. However, it must be remembered that information of that kind may be so used *only when such information is elicited for the purpose of treating the patient.*

When information is elicited for the purpose of leading the physician to form an opinion, regarding which he can testify for the patient as a witness only, such information is not admissible in evidence on behalf of the patient. This is incorporated in the decision in another New Jersey case.[5]

In still another New Jersey Supreme Court decision,[6] the Court said: "While a witness who is not an expert may testify only to such exclamations and complaints as indicate present existing pain and suffering, a physician may testify to a statement or narrative given by his patient in relation to his condition, symptoms, sensations and feelings, both past and present, because in this way only can the bodily condition of the patient be ascertained."

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[3] Miller *vs.* State, 9 Okla. R., 255.

[4] Koske *vs.* D. L. & W. Ry. Co., 142 Atl. R., 43.

[5] Lambertson *vs.* Consolidated Traction Co., 60 N. J. R., 452.

[6] State *vs.* Gruich, 96 N. J. R., 202; 114 Atl. R., 547.

Thus it will be readily seen from the very nature of this situation, relative to the admissibility of hearsay testimony and evidence, that it obviously becomes a matter almost entirely and exclusively under the control and discretion of the courts and lawyers and *not at all under the control and discretion of the witness on the stand.*

Whether or not certain testimony becomes admissible or is to be rejected as inadmissible hearsay evidence, depends entirely upon the conditions and circumstances under which it is offered. What may be decided to be proper and acceptible in one case, may be rejected as improper in another. Considerable more of what is commonly considered to be hearsay testimony, such as the recital of symptoms, pain, dying declarations, records, etc., is often allowed in connection with medical opinions and medical expert testimony than in any other kind of testimony. However, while the narration or recounting of symptoms and patient's complaints may be admissible when given in the testimony of a physician, the same testimony is not admissible when it is given by other persons than physicians, and physicians are not permitted to testify as to opinions based thereon. This is the meaning of an Arizona Supreme Court decision.[7]

And, as is elsewhere stated, even expert witnesses may give expert testimony only concerning matters in which they have qualified as experts.[2]

Referring back to the lowered opinions of the judiciary, the bar, the press, and the public relative to expert testimony, an example of what was thought of this subject by a leading New York newspaper, nearly forty years ago, may be gleaned from the following editorial published in the *New York Journal* for Oct. 2, 1897.

"*A Lesson in Expert Testimony.*[8]—"Mr. Anthony Comstock has encountered an unexpected obstacle in his crusade for the purification of all minds but his own. Having been informed that a certain Hebrew book was (*sic*) congenially filthy, he haled a dealer who sold it into court, and produced an expert interpreter who translated certain selected passages in a manner highly satisfactory and unfit for publication. Thereupon the defense produced another expert in Hebrew pornography, and this authority translated the suspicious paragraphs in a way that could not bring the blush of shame even to the sensitive cheek of Mr. Comstock. The court was at sea, and finally adjourned the case, to enable the parties to amass more contradictions from conflicting linguists, which each side promised to do.

"There must be judges in New York learned in the Hebrew tongue, and it would seem as if this controversy might have been brought before one of these for a judgment independent of the Comstock and anti-Comstock philogogists. But the incident neatly illustrates the value of expert testimony, as our legal system has developed it. There is only one thing less to be depended upon in court than an expert, and that is another expert. The only way to attain any approximation to trustworthiness in this class of testimony is to have the experts employed by the public in the interests of justice, and not in the interests of either side. The specialists might have fewer jobs under that system, but they would command more respect."

FEES

The subject of medical expert testimony can scarcely be considered to have been discussed unless at least some mention has been made of expert witness fees.

Before taking this subject up at all, it should be stated in no uncertain terms

[7] Security Benefit Assn. *vs.* Small, 272 Pac. R., 272.

[8] I am indebted for the foregoing to Dr. Ramsay Spillman, of New York City, a radiologist who thinks much as I do relative to medico-legal matters. He found this while browsing through some old newspaper files in the Congressional Library in Washington. He wrote me: "I thought, as I laboriously copied it in pencil on the back of an envelope (all I had with me to write upon), *this will be nuts for Trostler.*"

When I have induced men of this type to think of me when they see something that will be "nuts" for me, I feel as though I have done considerable toward making my colleagues and confrères law-conscious, and that my efforts have been worth while.

that it is absolutely improper and unlawful to undertake to give expert testimony on the so-called contingency basis, for a share or portion of the amount of the award of the court. There are several well-recognized decisions upon this.[9,10,11,12] In the case of Matter of Shapiro, 144 N. Y. App. Div. R., 1, an attorney was disbarred from practice because he had made an agreement with a physician wherein the latter was to receive a portion of the amount recovered, in payment for his services as an expert witness.

In Davis *vs.* Smoot, 97 S.E.R., 488, a North Carolina case in which a physician had arranged for and collected 20 per cent of the amount of the judgment, amounting to $125.00, as expert witness fee, the witness was compelled by the trial court to immediately repay the amount of his fee, and was rightfully threatened with contempt of court action if he failed so to do. The case was appealed to the Supreme Court of that State, which court, in deciding to concur with the judgment of the lower court, suggested bringing charges of perjury and said, in part:

"These issues were submitted to the jury in this action against the physician: (1) Did the defendant knowingly, designedly, willfully, and maliciously and unlawfully charge A. M. Davis 20 per cent of the amount recovered by A. M. Davis from the city as alleged in the complaint? *Answer:* Yes. (2) What amount, if anything, is the defendant indebted to the plaintiff? *Answer:* $125."

The defense was rested on the ground that the agreement was void as against public policy, and hence that the money having been paid, the plaintiff administrator could not recover it back. It is public policy that such a transaction as this cannot be allowed to stand simply because the defendant has been able to enforce payment of the illegal exaction.

Besides, there was in this case evidence that the defendant physician had administered to the said A. M. Davis morphine and other medicines, that the latter's mind while the defendant was visiting him and giving him morphine was in a very unsatisfactory condition, and that the defendant, who "had made a very good witness," collected the $125 with great promptness after the aforenamed A. M. Davis had received it.

The ground of the recovery sought by the plaintiff administrator was not that the defendant swore falsely in favor of A. M. Davis, but that he made representations that his testimony would be more effective if he were paid 20 per cent of the amount that the aforenamed A. M. Davis recovered, and after the trial he collected said 20 per cent out of the client over and above the fee of $10 allowed by the court.

"This court will not only not enforce a contract of this kind, but will compel repayment when collection has been made and there is evidence that the party making payment was under treatment and also under the influence of morphine administered by the defendant until after the money was paid him, and that thereafter when his physician was changed the patient's mind improved, and he made an effort to secure the return of the money.

"On the verdict on the first issue, that the money had been 'designedly, willfully, maliciously, and unlawfully collected by the defendant,' the court very promptly gave judgment for its return. No court in a proper sense of its own dignity and of purity in the administration of justice, which should always be above suspicion, could permit such a transaction to stand, simply because the offender had been quick enough to secure payment before proper action could be taken.

"The defendant on the verdict was guilty of gross contempt of court. It is commended to the consideration of the court below, whether, on the evidence in this case, proceedings in contempt should

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[9] Clifford *vs.* Hughes, 139 App. Div. R. (N. Y.), 730; 124 N. Y. Supp., 478.

[10] State *vs.* First Bank of Nickerson, 184 Neb. R., 163; 207 N. W. R., 674.

[11] Miller *vs.* Anderson, 183 Wis. R., 163; 196 N. W. R., 869; 34 A. L. R., 1529.

[12] County of Campbell *vs.* Howard, 113 Va. R., 19; 112 S. E. R 876.

not be brought by the court in vindication of public justice, and it is for the solicitor to consider whether a bill hsould not be laid before the grand jury for indictment for perjury in view of the intimation by the defense in this trial that A. M. Davis was unduly benefited by the too favorable testimony of the defendant in the trial of the action against the city. The transaction is not one that the court can in justice allow to go off without investigation. Such conduct by a witness as was here described and indicated by the verdict, strikes at the very heart and root of the administration of justice. The courts cannot be too careful and scrupulous in this particular."

I do not believe that anyone will deny that the knowledge that we, as physicians, have acquired in and of our profession, is the only thing we have to sell or otherwise dispose of, in order to "support ourselves and families and contribute to the relief of" such others as we deem fit. Our knowledge is our property. It is our stock in trade, as it were. We attended schools and colleges, spent large sums of money and many years of time to acquire this knowledge, and in all honesty and equity, no one, either individual, corporation, court, or state, has or can have a lawful right to take it from us without making adequate payment for the same.

Reasoning from the foregoing premise, we contend that when any physician, surgeon, or other specialist has been called as anything except an ordinary witness, he is entitled to and should receive a fee commensurate with his standing in his profession and the service rendered in any capacity, whether it be for giving expert testimony, the performance of a difficult surgical operation, or the diagnosis of and treatment for typhoid fever, or any other medical or surgical service.

If the party to the suit, calling a physician as an expert witness, desires that the testimony of such witness be backed up or reinforced by special study or research along certain lines, special arrangements should be made beforehand and any such arrangement regarding the expert's fees or remuneration are recoverable, if it becomes necessary for the witness to sue for the same. There are numerous decisions from State supreme courts upholding decisions by trial courts regarding the foregoing.

But when the physician enters the case as a subpœnaed witness, and is compelled to qualify and testify as an expert, without being able to collect more than the statutory mileage and *per diem* of ordinary witnesses, we feel that he has a just right to complain, and to insist that he is being compelled to deliver and give up his valuable property; in fact, all that he has to sell, without just and proper compensation.

The practice of serving a *subpœna deuces tecum*, commanding a physician to appear in court at a certain time and to bring with him certain roentgenograms or other documents is a common procedure, and in far too many instances, after the presentation and identification of the roentgenograms or whatever documents are involved, the physician is compelled to interpret the roentgen findings and to give expert testimony, even to the answering of hypothetical questions. If he even so much as hesitates to do all this, he may be threatened with being charged with contempt of court, and be subject to fine or imprisonment or both. That is the rule in Illinois, and much complaint is heard against it, but with little hope of remedy or relief under present conditions. Once in a while, some of us are able by certain technicalities, to evade these sharp practices by equally sharp ones. An example of this is related in the following incident, in which the judge was against his will induced to say: "*The witness does not need to answer.*"

About twelve years ago one of our eminent jurists was the guest speaker at a medical meeting in Chicago. During the discussion of his presentation he was asked whether a physician subpœnaed as an ordinary witness to identify roentgenograms, could be compelled to give expert testimony, interpret roentgeno-

grams, and answer all questions, without being paid an expert's witness fee.

The learned judge very emphatically informed those present that, if they failed to answer all questions propounded to them as witnesses, in his court, they would be in contempt of court and if they persisted in refusing to answer, they would be fined or imprisoned.

Some six or seven years later, a roentgenologist was summoned into the court presided over by this really eminent jurist, by means of a "*subpœna deuces tecum*," after having been paid the statutory $1.25 witness fee. After this witness had presented and identified the roentgenograms, he was asked to interpret them. This he did, not because he wanted to do it, but because he knew that he could and would be compelled to do so.

After the interpretation of the roentgenograms one of the attorneys propounded an hypothetical question to the witness. This the witness declined to answer. The attorney promptly appealed to the judge to compel the witness to answer and His Honor as promptly said, "The witness will answer." Witness replied that he could not answer the question, whereupon the judge insisted that he answer the question or be declared in contempt of court.

Looking the judge squarely in the eyes, the witness said, "Your Honor, if I answer that question, I will have to perjure myself, and if you insist upon me committing perjury, I will have to insist that you promise me your protection against the charge of perjury."

Glaring at the witness, the now decidedly irate jurist said, "The witness does not need to answer," and the witness was excused.

The procedure necessary to accomplish this is simple and effective. It has been used by a few men whom I have instructed.[13]

While it is true that in many States qualified witnesses may be compelled to give expert testimony at the same *per diem* and mileage as are paid to ordinary witnesses, quite a few States have statutory and other enactments and court rules giving the courts power and authority to award additional compensation for those giving expert testimony if the same is deemed advisable.

In Pennsylvania, the law authorizes district attorneys and other officers of the court to incur expenses for the investigation of crime which can be added to the costs of the prosecution. This provision has been applied for the purpose of retaining physicians to testify whether or not arrested motorists were intoxicated. In New York, Indiana and a few other States, witnesses need not give expert testimony unless these are paid fees adequate to the value, as we see it, and it has been decided that expert witnesses may collect adequate, just fees when, as, and if they render such services.

In other States the court or court officers have certain inherent rights—or assume such rights—which while not specifically authorized by law, enable them to incur expenses for investigation necessary to aid in justly deciding any case, either criminal or civil, and in that manner enable the courts to award to expert witnesses extra compensatory fees for their expert services, in addition to the ordinary *per diem* and mileage.

The writers of text-books differ considerably in their opinions and pronouncements upon this subject, and unfortunately most courts and jurisdictions follow the rules laid down by those who hold and contend that the refusal of any witness to answer any question which he may lawfully be required to answer, is a contempt of court, and if he persists in his refusal, he may be punished accordingly.

A case decision which has been rather widely quoted, and aroused considerable interest, will be excerpted for the benefit of interested readers.

A woman sued the City of Springfield, Illinois, and the trial came up in the Circuit Court of Sangamon County. Dr. Dixon,

[13] If any radiologist desires the particulars, he may have them by sending a stamped addressed envelope to the writer.

a well known physician, was subpœnaed by the city. He testified that he had practised as a physician and surgeon in Springfield for the past twenty-five years, that he was a surgeon for five railroads, that he was a graduate of regular schools of medicine, and that he had been doing general surgery for the past eighteen years. He was then asked an hypothetical question, the import and contents of which do not matter here.

The Doctor declined to answer, giving as his reason that an expert witness is entitled to a different and greater compensation than an ordinary witness, that he is not required to give expert testimony unless a reasonable compensation be paid or provided for. He stated, "A reasonable fee for an expert or professional opinion in this case is $10.00. I have not been paid nor offered anything for compensation for my expert or professional opinion in this case, nor has said compensation been in any way promised to me or provided for. On the contrary, it has been refused. Therefore, I decline to testify until such fee is provided for."

It was conceded that the witness knew nothing about the facts of the case, and was called as an expert only. It was also conceded that the charge of $10.00 as a fee, if a legal one, was very reasonable; but it was claimed that the city had no means provided for paying such fee, and had consequently not promised to pay the same.

The Doctor, in reply to another request from the court, again declined to answer because he had received no fee nor any promise of a fee as an expert. Thereupon the court informed him that he was not entitled to receive any such fee, but that it was his duty to testify as an expert witness. The witness further stated that he was not willing to testify, although informed by the court that it was his duty to do so, and continued to refuse to answer the question.

The clerk of the court was then directed to docket a case against the witness for contempt, and the court stated to the Doctor that it was the order of the court he should answer the question; but he still declined to do so. Thereupon, the court found him guilty of contempt and for such contempt fined him $25.00. This order fining the witness was excepted to by his counsel, who made a motion for the remission of the fine, which motion was overruled by the court. Exception was taken to the overruling of the motion and an appeal was made to the Appellate Court.

The Appellate Court of the Third District of Illinois affirmed the decision of the Circuit Court and upon appeal to the Supreme Court, Justice Magruder of that body delivered the following opinion:

"The question in this case is, whether a physician, who has been subpœnaed and is interrogated as an expert witness only, can be punished for a contempt for refusing to testify, when no compensation, greater than that allowed to an ordinary witness, has been paid to him or promised to him.

"The question involved has never been directly decided by this court. . . .

"It follows that, in this case, the court could not fix a compensation to be paid to appellant, nor order his fee of $10.00 to be taxed as costs, or order that the party calling the witness pay or secure his compensation. It is claimed, however, that in a civil suit a witness who is called to testify as an expert only, should not be punished for contempt in refusing to testify because no compensation is provided for his professional opinion other than the ordinary witness fees. The power to compel the production of testimony, necessary to the decision of issues involved in pending lawsuits, is one of the rights and powers, which is inherent in the very organization of courts of justice. Contempt of court is a disobedience of the rules or orders of the court, which interferes with the due administration of the law (3 Am. and Eng. Ency. of Law, p. 777). The refusal of any witness to answer any question, which he may be lawfully required to answer, is a contempt of court, and if he persists in his refusal he may be punished accordingly (Samuel *vs.* People, 164 Ill., 379).

"The grounds upon which the right to such extra compensation on the part of expert witnesses has been sustained, have generally been three in number. The first ground is that the time of the expert witness is more valuable than the time of ordinary men, and that, by attendance at court to give his testimony such witness meets with a loss of time. The better and more recent authorities, however, both in England and this country, now unite in the view that the right to such extra compensation cannot properly rest upon loss of time as a basis . . . . Manifestly the witness who goes to court and testifies as to facts of which he knows is subjected to a loss of his time as much as a witness who goes there to testify as an expert upon a mere matter of opinion.

"The second ground upon which the claim for such extra compensation is based is, that the skill and accumulated knowledge of the expert are his property, and that a man's property should not be taken without just compensation. Various definitions have been given of property. Webster defines property to be 'the exclusive right of possessing, enjoying and disposing of a thing.' . . . Blackstone says: 'Property consists in the free use, enjoyment and disposal of one's acquisitions without any control or diminution, save only by the laws of the land.' It has also been said that property in its legal sense is not the thing itself, but certain rights in and over the thing, these rights being: (1) user; (2) exclusion; (3) disposition. This court has also said in discussing the right to make and enforce contracts as being excluded in the rights to acquire property, that the laborer has the same right to sell his labor, and to contract with reference thereto, as has any other property owner. Labor is defined by Webster to be 'physical toil or bodily exertion,' and also to be 'hard muscular effort directed to some useful end, as agriculture, manufactures and the like.' He also defines labor to be 'intellectual exertion, mental effort, as the labor of compiling a history.' It is not exactly accurate to say that the more abstract knowledge, acquired in the study of a special employment, is of itself property. It is the right to apply that knowledge to the accomplishment of a particular result which constitutes property. For instance, if the appellant had been required to answer a question put to him with a view of prescribing a remedy for the relief of Mrs. P——, the plaintiff in the suit in which he was called to testify as a witness, then it might be said, if he was not offered any compensation, that he was deprived of a property right. But when a physician is asked an hypothetical question, and is called upon to give his opinion upon the facts stated in the hypothetical question while he is testifying as a witness in court, he is not thereby required to practise his healing art; he is merely making a statement, not for the purpose of effecting a cure or relieving a patient, but for the purpose of enabling the court and the jury to understand correctly a case, which is before the court. There is no infringement here of a property right. It may be conceded that in a certain sense, the knowledge of the physician, acquired by special study, is property, but the question here is, not so much whether certain knowledge is property, as whether the requirement that he shall answer an hypothetical question is a taking of his property. Where he is required to make an application of his knowledge to a particular case so as to secure a particular result, such as, for instance, the curing of a disease or the healing of a wound, then he would undoubtedly be entitled to compensation . . . . Counsel for appellant state that many of the cases which have held that expert witnesses can be required to testify without being paid are criminal cases, where the interest of the State and the interest of the public demand of the physician that he should yield up something of his knowledge for the benefit of society at large. This position, however, is inconsistent with the contention that when an expert witness is required to testify without compensation, his property right is interfered with. A man's property cannot be taken from him by the

State without compensation. It makes no difference whether it is to be taken for the good of the public or for the benefit of a private individual, as far as the right to compensation is concerned. It is true that private property cannot be condemned by the State for a private purpose. Private property can be taken only for a public purpose. But in either case, it must be paid for. To concede, therefore, that in a criminal prosecution conducted by the State, a physician may be required to testify without compensation because it is for the public good, is to concede that his knowledge may be made use of by a court of justice without his being paid therefor. We conceive, however, that it can make no difference whether the suit in which the witness is called to testify is a suit between private parties or is a suit between the State and an alleged criminal. In either case the object is to promote public justice. It is just as important to the peace and good order of society that private controversies should be settled upon correct proofs and in accordance with truthful testimony, as that criminals who violate the laws of the State should be punished. It is the duty of the ordinary witness and of the expert witness to testify to the facts within their knowledge, which bear upon the decision of controversies in courts. Such duty devolves upon each citizen, and in view of the protection which he receives from the laws of the country in the matter of his personal liberty, and in the matter of the protection of his property. The duty devolves as much upon a physician who is required to testify as an expert witness in answer to hypothetical questions as it does upon ordinary witnesses testifying to facts within his knowledge.

"In Vise *vs.* County of Hamilton, 19 Ill., 78, we held that an attorney appointed by the court to defend a criminal could not recover for his services from the county in which the prosecution was conducted, and that a court might compel an attorney, as one of its officers, to defend a prisoner in case of his inability to employ counsel. It has never been supposed, that to require the performance of such professional services without compensation was the taking of property without compensation.[14]

"If the precedent is once established that expert witnesses must be paid reasonable compensation for their testimony, then it will not be long before such testimony will be offered to the highest bidder. The temptation will be to give opinions in favor of that party to the suit who will pay the highest price. The testimony of expert witnesses will soon become partisan and one-sided. The theory upon which such witnesses are required to testify in cases like this is that they are *amici curiæ;* and that testifying under the sanction of an oath, they do so not with the intent to take the part of either contestant in the suit, but with a view of arriving at the truth of the matter and for the purpose of aiding the court to pronounce a correct judgment. In Redfield on the Law of Wills (p. 155, Sec. 51, note 46) it is said: 'It being merely a matter of conventional arrangement between the professional experts and those who desire to employ them as witnesses both in regard to their acting as such, and also to their making preparations to enable them to give their testimony, it virtually places a price upon such testimony in the market, and its price is likely to range somewhat according to its ability to aid one or the other parties litigant. The tendency of this is to render it partisan and one-sided, as a general thing.'

"Moreover, if a physician is to be allowed extra compensation as an expert witness, then men pursuing other occupations which require expert experience will have the same right to demand extra fees. A banker will claim that he has earned extra compensation; a merchant will make the same claim; and so with men engaged in other branches of business. It will be easy to say in such cases that

[14] AUTHOR'S NOTE: To bring the analogy a little closer may we not say that *it* would *most assuredly be supposed that to require such professional* LEGAL *services in a* CIVIL *suit without compensation, would be the taking of property without compensation.*

the testimony called for is the result of special knowledge and acquired skill and, therefore, should be paid for. Almost every lawsuit involves testimony which is in the nature of opinion in addition to testimony which speaks of the mere facts within the knowledge of the witnesses. . . .

"Counsel for the appellant also claim as a third ground, that the accumulated knowledge and skill of the expert witness, if not as property, yet is 'particular services.' This contention is based upon the reasoning of the court in Buchan *vs.* State, 59 Ind., 1, which is the leading case upon this subject in opposition to the views here expressed. That case proceeds mainly on the ground that the services called for are included within 'particular services' as these words are used in the Constitution of Indiana. Section 21 of the Indiana Bill of Rights provides, 'No man's particular services shall be demanded without just compensation.' The Indiana court there held that the services of an expert witness were 'particular services' and that, therefore, under the Constitution they should be paid for. No such provision as the one referred to as being contained in the Constitution of Indiana exists in the Constitution of Illinois. Counsel for the appellant say, however, that Article 2 of the Ordinance of 1787 provided. . . . However this may be, the Ordinance of 1787 is not in force in the State of Illinois.

"The decision in Buchan *vs.* State, *supra*, was rendered by a divided court consisting of five judges. Two of the judges, Chief Justice Biddle and Judge Niblack, dissented from the opinion in that case. The views of the dissenting judges are given in the case of Dills *vs.* State, 59 Ind., 15, and the reasoning there is cogent and convincing; and the opinion adopts the views of the Supreme Court of Alabama as announced in the case of Ex-parte Dement, 53 Ala., 389. The latter case is the leading case in this country in favor of the views herein expressed; and its line of reasoning is substantially adopted in what has been here stated. That case holds that the law allows no excuse for withholding evidence which is relevant to the matters in question before its tribunals, and is not protected from disclosure by some principle of legal policy; . . .

"Upon this subject, Rogers, in his able and exhaustive work on Expert Testimony (Sec. 188, p. 424, 2nd ed.), says; 'There can be no doubt that professional men are not entitled in this country to claim any additional compensation, when testifying as ordinary witnesses to facts which happened to fall under their observation. But another question arises, when they are summoned to testify as to facts of science, with which they have become familiar by means of special study or investigation, or to express opinions based upon the skill acquired from special researches as to conclusions which ought to be drawn from given facts. Whether they can be compelled to testify in such cases, when no other compensation has been tendered than the usual fees of ordinary witnesses testifying to ordinary facts, is a point upon which the cases are not in harmony. In this country, the cases are nearly balanced, and the question must be regarded as still an open one, although the weight of authority rather inclines to the theory that the expert may be required to answer the question without additional compensation.' As has already been stated, we prefer to adopt the views announced by the Supreme Court of Alabama and in the cases following the Alabama decision.

"We cannot close this opinion without quoting and endorsing the following views expressed by the Texas Court of Appeals in Summers *vs.* State: 'It is to be regretted, that a member of a profession with so distinguished and high sense of honor and duty should refuse to testify in a case pending before the courts of his country, involving the life of a fellow being, and the rightful administration of the law of a common country. Dr. Spohn has doubtless been misled in taking the position he did by the misconceptions of certain writers on jurisprudence.'

"For the reasons above stated we have arrived at the conclusion that the judgments below were correct. Accordingly, the judgments of the Appellate Court and of the Circuit Court are affirmed."[15]

From the above-excerpted decision, we learn that we can be punished for contempt, if we refuse to answer questions of any and all kinds, as ordinary or as expert witnesses, when we are on the witness stand in Illinois and probably other States in this vicinity. But this is only partly true, because sometimes the presiding judge says, "The witness need not answer," as previously related.

While it may be an instance of a "fool venturing where angels fear to tread," I cannot help saying that evidently the Supreme Court of this State feels that we are not practising medicine unless we are prescribing for patients, when it said in the foregoing decision: "If the appellant had been required to answer a question put to him with a view of prescribing a remedy for the relief of Mrs. P——, the plaintiff in the suit in which he was called as a witness, then it might be said, if he was not offered any compensation, that he was deprived of a property right." How different our methods of ratiocination must be from those distinguished justices of our Supreme Court! We, who daily give so much of our time, knowledge, and services in the treatment of the indigent sick and suffering, are, according to the learned gentlemen just mentioned, giving property away; but when that same identical knowledge is taken from us, against our will and without payment, it ceases to be property and becomes as free as the air we breathe. If that kind of reasoning were not so tragic, it would be funny. Certainly it is ridiculous, and almost certainly if that case had been carried up to the United States Supreme Court, it would have been reversed, because at that time our good friend, the late William Howard Taft, was on that high bench, and would have seen just a little more from our aspect than did others.

[15] Dixon *vs.* People, 168 Ill. R., 179.

According to the way this last decision was reasoned out, it would be robbery, if a man took another's money by force, if the robber intended to and did use the money to buy cigars or perhaps pay a Doctor's bill, *but*, if he intended to (and perhaps did) pay his pal's fine or defray the expenses of his brother's trial for murder, it would not be robbery. The analogy is not so very unlike, is it? Or is it our fault, in that we do not know how to reason correctly regarding this matter? If it is the latter, and we do not know how to reason it out, I, for one, do not want to learn how to think that the knowledge of the medical profession, acquired by the many years of toil, study, research, etc., is not property, as much as anything can be. And furthermore, I propose to resist the taking of that property from me, without just compensation, as long as I am able to fight.

Because of the variations and differences in the prevailing laws and practices relative to the payment of witnesses who render expert testimony, it has become the custom to have the expert witnesses paid by the litigants, particularly in civil suits. However, as previously indicated, several States by express statutes provide for payment of special or extra fees to expert witnesses, the amounts of such extra fees being in some States left to the discretion of the court, while in several of these States provisions for authorizing the district attorneys to procure the services of expert witnesses in criminal cases, and to obligate the county to pay reasonable compensation for same, are in operation.

It must be understood that when one of the litigants employs a witness to give expert testimony, the fees for such witness cannot under any circumstances be included in the court costs of the trial of the case, and be reimbursed for, if the opposite side of the suit has to pay the costs of the litigation. The fees which are paid to expert witnesses cannot be recovered from the adverse party in the suit, but must be borne by the party calling the witness, irrespective of the outcome of the trial.

Quite a considerable number of suits to recover fees due expert witnesses have been decided, almost always in favor of the expert witness. A recent New Jersey case[16] is particularly interesting. The plaintiff in this case (a roentgenologist and member of this Society) had been employed by the attorney for a woman who was suing for damages in a personal injury case, and had rendered services as an expert witness, the roentgenologist rendering a bill for $100 for his fee. The woman claimed that, not having personally contracted for his services, she was not obliged to pay. Dr. Klein brought suit and at the trial, the judge took the case from the jury on the ground that no case had been made. The Doctor then appealed to the New Jersey Supreme Court.

The Supreme Court of New Jersey said, in effect, that:

"An attorney has no authority under his retainer to surrender or waive without the consent of his client any substantial legal right. But when the defendant's attorney obligated his client to the extent of $100, he did not surrender or waive any of his client's substantial rights. His act was that of a careful and prudent attorney, to protect and promote his client's interest. It is common knowledge that, when one has sustained serious injuries, roentgenograms are frequently made by experts to determine the nature and extent of such injuries; that an expert is necessary (*sic*) to interpret such roentgenograms, and that it is the common practice to use the testimony of such experts, whenever available, in a suit to recover damages for such injuries. Further, if the propriety of a challenged expenditure for which the defendant denied liability is to be judged by the result obtained, the defendant's failure to challenge either the necessity of the expert testimony given or the reasonableness of the fee charged is readily understood; in the case in which such testimony was given, the defendant in this case, who was the plaintiff there, recovered a verdict of $15,000.

"It is far from a mere conjecture that, if the attorney had failed to produce this expert testimony—and he could not produce it unless it was volunteered, without arranging for the payment of the expert—he might well have subjected himself to a claim of negligence, at the suit of his client. The Supreme Court is of the opinion, therefore, that an attorney who is retained to prosecute a suit for damages arising out of an accident has implied authority to obligate his client to pay the fee of an expert witness whom he employs to testify in behalf of such client, when the necessity for such a witness and the reasonableness of his fee are not challenged.

"Accordingly, the judgment of the district court, withdrawing the case from the jury, is reversed and the case remanded for trial."

The foregoing apparently solves at least one problem relative to the fees of expert witnesses. Parties to personal injury damage suits are liable for the fees of expert witnesses, if the services of the witnesses are contracted for by the attorney of the aforementioned party to the suit.

[16] Klein *vs.* Boylan, 179 Atl. R., 638.

THE AMOUNT OF EXPERT WITNESS FEES?

In February of this year a radiologist in a city of about 43,000 population, in a central State, wrote me: "I want to thank you for the effort you have made to educate your fellows concerning the rights and good practices of radiologists in medico-legal cases.

"It so happens that I am often called to testify as an expert witness and for this I have received the grand sum and total of $4.00 a day.

"Will you kindly let me know what you consider a fair charge in an average case, testifying as an expert witness? I understand that this would vary with the case, but I wish to have a figure from which to vary."

My reply was: "*Re* fees for radiologists (or other physicians) who give expert testimony, will say that that depends very

much upon the geographic location of the trial at which the testimony is given, the distance travelled by the witness, the seriousness or gravity of the case, whether it involves a hundred dollars or a hundred thousand dollars, the length of time that the witness is on the stand (if local) or away from his office (if distant), and last, but by no means least, the standing and reputation of the witness himself.

"I would say that in a city the size of yours, when called as an expert witness and not more than one hour is consumed, a fee of $25.00 should be the minimum. If a half day was consumed, it should not be less than $50.00; while if it was a very important case in which a large amount of money was involved, and the expert's testimony was one of the critical points upon which either the decision or the amount of the verdict hinged, the fee should not be less than $100.00, and from that up. If a specialist has to go to some other city or town, the fee should be not less than $50.00 per day and expenses, if within the same county, and relatively more outside of the county. For the same service at greater distance, the fee should be approximately $100.00 per day and expenses, except when or where the outcome of an important case hinges on and depends in a large measure upon the expert's testimony, in which event I have advised—and charged—up to $500.00 per day, and do not consider that amount excessive in suitable instances. Of course, the latter sort of cases are rare; but we must be prepared to embrace such opportunities when they present themselves. I received the latter fee just once, but my services were worth that much or the people who had me come five hundred miles would not have been willing to pay it.

"Trusting that this will give you my ideas relative to the matter, and that you will be able to boost your fees much over the four-dollar mark, which to me appears to be ridiculously inadequate for an expert witness," etc.

While the foregoing is merely "a drop in the bucket" as regards what we might write relative to this broad subject, we sincerely hope that this contribution will add a "wee bitty" to what we should know regarding expert testimony.

(*To be continued*)

CHRONIC RECURRENT INTUSSUSCEPTION IN AN ADULT ASSOCIATED WITH ADENOCARCINOMA OF THE CECUM

A CASE REPORT

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A REVIEW of the available literature reveals that only 20 per cent of all intussusceptions occur in patients over two years of age, and only 5 to 10 per cent in adults. The acute form is rare after puberty, and most chronic cases are found in patients from thirty to fifty years of age. There is a definite predominance in males, the ratio given being from two to three males to one female (8, 10).

Tumors are frequently found associated with, or as the causitive factor in, adult intussusceptions. Mayo (10) states that 85 per cent of all adult intussusceptions are produced by tumors, and further that 67 per cent of these tumors are malignant. Other authors (8, 13, 15) stress the fact that benign tumors, particularly of the small bowel, are more common than has been previously reported, and that they are frequently associated with intussusception.

Other causes of intussusception in adults are given as tuberculous and other infectious processes of the bowel, inverted appendix, inverted diverticulum, Meckel's diverticulum, anatomic and pathologic variations in the mobility of the cecum and ascending colon, irregular peristalsis, and unusual muscular effort.

The relationship between the presence of a tumor in the bowel and intussusception is not entirely clear. The prevailing theories are as follows:

(1) That the tumor acts as a foreign body, particularly if pedunculated. The bowel produces violent peristaltic movements in its attempt to dislodge the tumor, and, in pushing the tumor mass distally along the bowel lumen, the attached bowel wall is pulled along with it, inverted, invaginated, and propelled into the distal portion of the bowel by the violent peristaltic movements.

(2) That the weight and mass of the tumor itself may initiate the process, and then it is aided by peristalsis.

(3) That in those cases in which the tumor is some distance proximal to the head of the intussusceptum, there has been a constriction of the bowel about the site of the tumor and a relaxation distally, so that in ordinary peristaltic action the entire segment is thrust forward into the distal loop.

(4) That there is sometimes perverted muscular action due to the presence of the tumor, and simple relaxation or paralysis of the bowel by the tumor.

(5) Finally, that in malignant disease of the bowel, the infiltration of the bowel wall by the malignant process, with resultant loss of elasticity and contractile powers, makes invagination of a more flexible proximal segment relatively easy.

The essential pathology of intussusception is that of restriction of the blood supply to the involved segments of bowel. The mesentery carrying the blood vessels to the bowel walls is constricted by the invagination. The veins are first occluded by this constriction, producing venous stasis but permitting arterial flow. The involved segments of bowel become edematous, particularly the middle and inner layers. The edema of the bowel results in further constriction of the mesentery, and finally the arteries are also occluded. There is an infiltration of blood and mucus into the lumen and a transudation of bacteria through the bowel walls into the peritoneum. Necrosis and gangrene of the involved bowel follow, though the outer layer is less likely to be so involved than the middle and inner ones.

This sequence of events is apparently not always found in chronic or recurring types of intussusception. Cases have been re-

ported (2, 4, 12, 17) in which the intussusception had been present for two weeks and longer without the production of gangrene or obstruction. Whether due to increased tolerance of the bowel to reduced nutrition, to gradual stretching of the mesentery and vessels, to increased mobility of the bowel and mesentery, or to marked dilatation of the intussuscepiens has not always been determined.

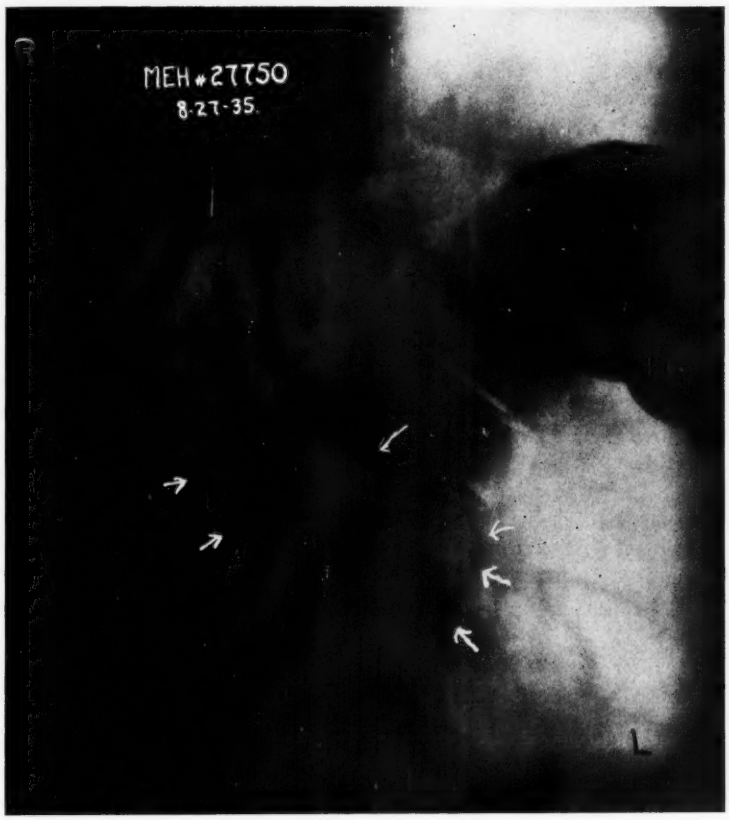

Fig. 1. "Spot" roentgenogram made with fluoroscopic unit. Site of intussusception and tumor before reduction, which is just to the left of the mid-line in the transverse colon.

The symptoms produced by these chronic or recurring forms of intussusception are indefinite and irregular. Gradually increasing constipation, which may be interspersed with periods of diarrhea, is frequently found. Blood in the stools is uncommon, but may be found in acute exacerbations. Generalized abdominal pains of a colicky nature are more often complained of than acute sharp pains. Nausea is sometimes present, but vomiting is rare. Gradual loss of appetite and some loss of weight and strength is common. The presence of a mass in the upper abdomen or in either side is relatively common, but it may be very transitory. Anemia is more often produced by malignant tumors associated with intussusception than by intussusception primarily. Other laboratory findings are not definitely characteristic.

The roentgenographic appearance of intussusception was first described by Lehman. Groedel, Snow, and Edburg have added to our knowledge of this subject.

Rutledge (16) and others have recently added extensive observations. In the ileal, or enteric type the barium enema is of no value except for exclusion of colonic involvement. In the ileocecal type, the head of the intussusceptum may pass far into the colon, with dilatation of the colon distal to it, and loss of normal haustral markings. In this type, the typical U-shaped deformity at the point of obstruction of the barium enema can usually be made out. In the ileocolic type, the primary invagination begins in the ileum, and it does not often extend so far into the colon. At times, the barium enema may be seen to pass between the layers, as the intussusceptum—largely the ileum—is smaller than in other types. The colonic form produces a similar appearance to that of the ileocecal form, although tumor of the colon has quite often been reported (16).

The successful and permanent reduction of some cases of intussusception by barium enema alone has been reported (16). Many authors feel it should be tried before surgery is resorted to, but the majority of cases require surgery after the diagnosis has been made. Mayo (10) believes resection to be the procedure of choice in chronic intussusception, since he has found such a high percentage of malignant tumors to be the causative factors in these cases.

We believe the following case is of interest and importance because of these facts.

There is an atypical history of malignancy even after prolonged observation, during which time no definite diagnosis had been made.

The intussusception recurred at intervals over a period of eight months, without producing obstructive symptoms at any time.

The intussusception was undoubtedly completely reduced at one time under the fluoroscope by another roentgenologist, and then returned shortly thereafter. It had been present without change in outward appearance or symptoms for over four weeks at the time we first saw the patient.

The intussusception was even then so easily reduced under the fluoroscope, that the usual adhesions between the bowel walls that form under such conditions in much less time could not have been formed in this case.

And finally, the type of mass or violent peristalsis that is believed by many to be a vital part in the production of intussusception in cases in which a tumor of the bowel is present, was observed under the fluoroscope.

CASE REPORT

Mrs. C. P., aged 69 years, was admitted to the hospital on Aug. 27, 1935, with the following complaints: Generalized abdominal distress at intervals, without severe pain at any time, for a period of eight months; slight constipation which seemed to be gradually increasing; slight loss of weight and appetite, and a peculiar irregular and often transient sensation of a mass, or "drawing sensation" in the right side of the abdomen.

There seemed to be no relationship between the indefinite pain and eating or bowel movements. There had been no nausea, vomiting, blood or mucus in the stools, diarrhea, chills, fever, urinary symptoms, referred pain, rash, or other manifestation of infection. The symptoms had developed gradually over a period of eight months, during which time she had been seen by a physician, but no definite diagnosis had been made.

Physical examination revealed little of significance other than a definite mass in the upper abdomen just to the left of the mid-line. This was rather firm, smooth, rounded, and somewhat tender to deep palpation. It could not be dislodged from its position by external palpation alone.

There was a mild secondary anemia with an erythrocyte count of 3,930,000 and hemoglobin of 78 per cent—12 grams. The urine was essentially normal and the kidney function was within normal limits. A stool examination was not made.

A roentgenographic examination of the colon had been made in another city six weeks prior to admission here. The diagnosis then made was of a movable mass in

Fig. 2. Fig. 3.

Fig. 2. Colon filled after reduction of intussusception. Note spasm and irregular contractions of the cecum. Tumor is not demonstrated. Colon dilated distal to location of intussusception.

Fig. 3. Roentgenogram taken after evacuation of barium enema. Irregular and fibrillary contractions of that portion of the colon involved by the intussusception. The arrows localize the farthest progression of the intussusception, and deformity of cecal wall near the tip. Small tumor mass could be observed fluoroscopically because of displacement of barium.

the transverse colon which could be forced into the cecum. No definite diagnosis of intussusception was made at that time, although we believe that an intussusception must have been present, in view of the later findings. The mass disappeared at that time, as it had done repeatedly in the previous months, but returned in a few days and had been constantly present from that time until admission without evident change in the symptomatology.

In our examination of the colon by barium enema, we found the enema obstructed in the transverse colon just to the left of the mid-line (Fig. 1). The obstruction was produced by an apparent intralumenal mass, which was shown by manipulation to fill the entire lumen. The mass was round, smooth, and showed nothing like the typical U-shaped deformity which one would expect to find in an intussusception. By using pressure behind the mass, it was readily moved from its original site in the transverse colon to the lower pole of the cecum (Fig. 2). It was found to be a single mass, smooth in contour, about the size of a small orange, and apparently attached only loosely, if at all, to the bowel. Frequent mass peristaltic movements appeared during the course of the examination. These movements always originated at the temporary site of the mass, and the patient complained of slight pains when these movements occurred. The bowel distal to the point of obstruction was dilated. No evidence of a pedicle to the mass could be made out, although on one film there was a suggestive strand of increased density which seemed to be attached to the inferior surface of the mass and connected with the bowel wall near the ileocecal valve. The tumor could not be pushed through the

ileocecal valve, nor could barium be expressed into the terminal ileum (Fig. 3).

In attempting to come to a logical conclusion from our findings, we considered seriously the possibility of this being a recurrent intussusception or fecalith. We felt, however, that the length of time the mass had been constantly present without change in symptoms, the lack of typical findings, the ease with which the mass could be moved about, and the suggestive appearance of a pedicle made the diagnosis of intussusception highly improbable. We also considered the possibility of this being a malignant tumor, but felt that there should have been more definite anatomic changes with such a long history. We concluded, therefore, that the mass was probably a benign tumor on a long pedicle. We were unable to determine whether the primary origin was in the cecum or terminal ileum.

At operation, immediately after our examination, the intussusception was not present, but the appearance of the bowel indicated to the surgeon that one had been present. It undoubtedly had been reduced under the fluoroscope pre-operatively. The appendix, cecum, and ascending colon were shortened and thickened. A tumor with a broad base could be felt inside the cecum. A resection of the cecum, ascending colon, and terminal ileum was done, and an anastomosis between the ileum and hepatic flexure was completed. Recovery from the operation was uneventful.

The pathologic report on the specimen stated that it was an annular papillomatous type of adenocarcinoma of the colon, located immediately around the insertion of the appendix. It measured six centimeters in its greatest diameter. There was no definite involvement of the neighboring lymph nodes.

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ROENTGENOLOGIC STUDY OF SACROCOCCYGEAL CHORDOMA

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CHORDOMA is a rare tumor which arises from the cellular vestiges of the embryonal notochord. It occurs most frequently in the spheno-occipital and sacrococcygeal regions, but primary chordoma has been reported to occur in other parts of the spinal column and the skull. Recently Stewart (1, 2, 3), Andler (4), Montgomery and Wolman (5), Hass (6), Adson, Kernohan, and Woltman (7), and Fletcher, Woltman, and Adson (8) have presented pathologic and clinical studies of this tumor, but very little has been reported on the roentgenologic diagnosis. In the more recent publications, x-ray examination is included in a larger number of cases, and, occasionally, roentgenograms are reproduced. Opinions, however, still differ widely in the estimation of the value of roentgenologic examinations. Most authors concur in that, in the spheno-occipital region, an x-ray examination would not reveal any characteristic or diagnostic evidence other than undifferentiated destruction when it is present. This is so probably because of the complexity of the neighboring dense structures and the comparatively small size of the tumor. In the sacrococcygeal region, where the bony parts are more accessible to direct roentgenologic examination and the tumor is generally larger in size when pressure symptoms are present, it is reasonable to expect that a roentgenologic examination would show more characteristic findings. In the present study, based on a review of published cases and our three proven cases, we are attempting to evaluate the roentgenologic findings of this tumor in the sacrococcygeal region.

REVIEW OF LITERATURE

Burrow and Stewart (2), in discussing the diagnosis of spheno-occipital chordoma, stated that a good x-ray film taken with a Potter-Bucky diaphragm might show evidence of absorption of bone or the outline of the soft tissue tumor, but, apart from the microscope, the exact pathology must remain obscure. Adson, Kernohan, and Woltman (7) found x-ray examination less helpful in the diagnosis of spheno-occipital chordoma. In one of their three cases, in spite of the fact that the tumor had originated from the region of the spheno-occipital synchrondrosis and had invaded the surrounding bone, little evidence of destruction of the bone was seen in the postmortem roentgenogram, and, in another case, in which the roentgenogram showed erosion of the upper three cervical vertebræ, the tumor behaved grossly more like a neurofibroma than a chordoma. However, in an article on chordomas of the cranium and the cervical spine, Hass (6) expressed the opinion that the clinical diagnosis of this tumor is difficult without the aid of roentgen examination or biopsy. In his case Sosman found in the roentgenograms a destructive process involving the occipital bone at the anterior edge of the foramen magnum and the arch of the atlas; there was also a large soft tissue tumor bulging into the posterior nasopharynx. Sosman gave the impression that the roentgen findings indicated a malignant process, possibly metastatic; however, he also stated that the only primary tumor in this region would be a chordoma. Hass mentioned also that the injection of iodized oil into the subarachnoid space may be of the greatest value in demonstrating the presence of an extradural tumor compressing the ventral surface of the cervical cord.

Syme and Cappell (9) reported a case of chordoma of the pharyngeal region which was illustrated with a roentgenogram showing marked destruction of the body of

the third cervical vertebra and commencing erosion of the bodies of the second and fourth cervical vertebræ. Cappell (10) recorded another case of chordoma occurring in the dorsal region, with x-ray evidence of abnormality of the fifth and sixth dorsal vertebræ, the intervening disc being apparently destroyed and merged in an ill-defined mass which involved both vertebral bodies; the discs above and below these vertebræ also appeared to be thinned. Davison and Weil (11) presented a case of chordoma on the left side of the cauda equina which showed sclerosis of the left half of the third lumbar vertebra on x-ray examination.

Fig. 1.

Fig. 2.

Fig. 1. Halter's case (14). Postmortem roentgenogram showing destruction of the sacrum which Halter considered as typical of chordoma.

Fig. 2. Wildbolz' case. Roentgenogram of a sacral chordoma showing characteristic changes. (Note expansion, vacuolation, and trabeculation of the involved bone.)

Zollinger (12) recorded a case in which the roentgenogram showed irregularity of the outline of the third lumbar vertebra, with narrowing and increased density of the left side of the vertebral body, suggesting an old compression fracture.

Hutton and Young (13) reported a case of sacrococcygeal chordoma in which the x-ray examination showed that the lower end of the sacrum was not easily distinguishable from the tumor, and the outline of the coccyx was quite indefinite; it was thought that there was some irregular bone formation in the second and third lumbar vertebræ. Halter (14) reproduced in his article a postmortem roentgenogram of the sacrum (Fig. 1), showing destruction of the bone which was reported as typical of chordoma. Gerber (15) found in the roentgenogram of his case of sacral chordoma a round shadow in the pelvic cavity at the lower portion of the spinal column but without changes in the bone; this was a case of antesacral chordoma. In Key and Berven's case (16), Akerlund described changes of expansion of the sacrum with multiple, spotty areas of destruction and suggested the possible diagnosis of chordoma. Wildbolz (17), in the roentgenologic examination of the sacrum of his case (Fig. 2), found changes which he considered as characteristic of chordoma, but did not describe the changes. Fletcher, Woltman, and Adson reported ten cases of sacrococcygeal chordoma, in four of which the roentgenograms gave evidence of destruction of the sacral vertebræ which, in appearance, suggested the presence of a malignant growth; in five the roentgenologic report was negative, but they suggested that with recent improvement of roentgenologic technic incidence of negative findings would probably not be so high. However, they considered that no roent-

genologic appearance diagnostic of chordoma, as distinguished from other malignant tumors, could be established and that tients, which showed the same honeycomb appearance in the region of a hypophyseal chordoma.

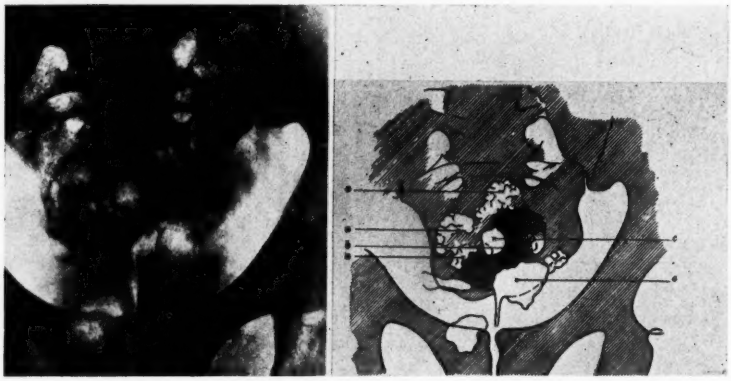

Fig. 3. Andler's case. Roentgenogram of the sacrum showing honeycomb destruction of the bone which Andler described as characteristic of chordoma. (*a*, typical structure of a chordoma; *b*, diffuse tumor shadow; *c*, air bubble.)

studies with iodized poppy-seed oil, 40 per cent, in the suspected cases of sacrococcygeal chordoma might produce diagnostic information before routine roentgenograms became positive. Andler (4), in his excellent article on sacrococcygeal chordoma, reported seven cases. In five, the roentgenologic findings were indicative of chordoma; one of these was illustrated by a roentgenogram (Fig. 3). The characteristic findings were multiple, small and large, radiotransparent areas distributed irregularly in the diffuse tumor shadow which replaced the normal bony structure almost completely and gave a net-like, honeycomb appearance, due to the contrast of the preserved, shadow-producing bony spicules and the partition walls on the one hand, and the tumor cysts on the other hand. The distribution of the transparent areas was irregular due to the appearance of the elastic parts in the firm connective tissue tumor. Outside of the sacrum and coccyx, the tumor shadow was more uniform, yet the radio-opacity varied there in accordance with the amount of the connective tissue and cyst-like structure. Andler also noted that the findings typical of sacrococcygeal chordoma were also present in cranial chordoma as was seen in the roentgenologic examination of one of his pa-

REPORT OF CASES

Case 1. A Chinese male teacher, 42 years of age, was first seen in this clinic on Feb. 28, 1933. His complaint was a tumor mass in the gluteal regions, of four years' duration. At the onset the patient had pain in both gluteal regions and a hard painful nodule about the size of a hen's egg in the right buttock. Several months later, two other masses developed at the same location; these grew and coalesced to form a large tumor. One year after the onset two new masses appeared in the left buttock which gradually increased in size and formed one large tumor with the masses in the right buttock. There was pain upon sitting. Constipation had been present for two years and frequent desire to urinate for eight months.

Physical examination showed a hard tumor mass of 20 × 20 × 15 cm., occupying the entire gluteal regions and stretching the perineum (Fig. 4). The overlying skin appeared normal in color but was adherent to the mass. The tumor itself was not movable. The superficial veins were congested. On rectal examination, a mass protruding anteriorly was felt.

Roentgenologic Examination.—The lateral view (Fig. 5) demonstrated a huge soft

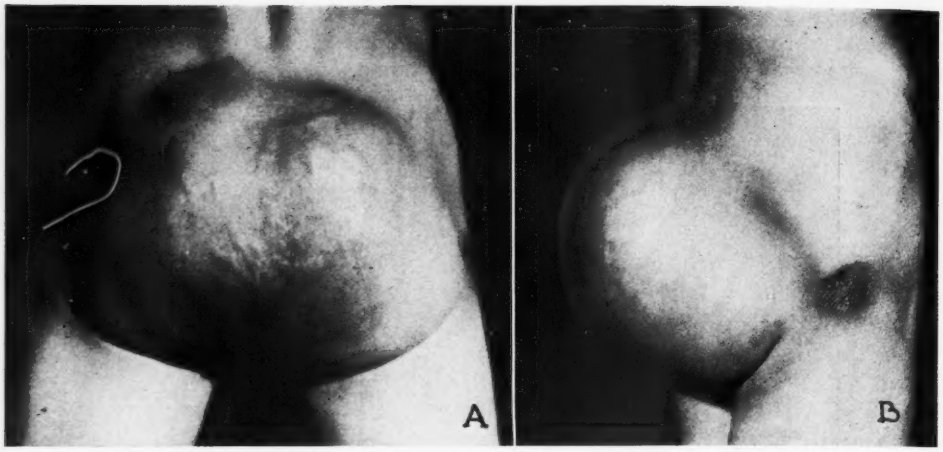

Fig. 4. Case 1. Photographs of the tumor in the sacral and gluteal regions. (*a*, posterior view; *b*, side view.)

tissue swelling in the gluteal region. The lower two-thirds of the sacrum and the coccyx were extensively destroyed. The anterior outline of these bones could be traced in places, but their posterior border was entirely absent. In the soft tumor mass, which extended mostly posteriorly, there were bony trabeculæ in the upper portion and considerable irregular masses of mild density in the lower portion. The appearance of the bony trabeculæ and the irregular, dense masses in the soft tissue tumor suggested a growth which had originated in the bones, destroyed them, and carried the bony fragments and débris into the gluteal mass. A roentgenologic diagnosis of chordoma was made which was confirmed by a needle biopsy and pathologic examination (Fig. 6).

The patient did not return to the clinic for further consultation.

Case 2. A Chinese male farmer, 62 years of age, came to the hospital on July 16, 1927, complaining of a large mass in the right buttock of two years' duration. He had a fall six months before the appearance of the tumor. The tumor grew steadily till it measured about 14.5 × 12 × 7.5 centimeters. The tumor was firm and fixed to the underlying bone but was not attached to the skin. The lateral border of the mass was movable and its consistency was like cartilage in places. There was occasional pain in the tumor. Pain along the right leg had been noticed for six months. Neurologic examination showed no definite involvement of the sciatic nerve other than probably stretching. Some difficulty in defecation and urination was present. Rectal examination revealed a prominence of the right border of the sacrum.

Roentgenologic examination of the pelvis in the anteroposterior view showed expansion of the lower portion of the sacrum to both sides; the bone was rarefied and trabeculated. In the lateral view the outline of the involved bone could not be defined except along its upper border. The roentgenologic diagnosis was giant-cell tumor or osteochondroma of the sacrum. (Unfortunately the roentgenograms are not available for reproduction.)

An exploratory operation was done. Several finger-like projections were felt under the skin and these were found to be tumor invading the gluteal muscle. The tumor was partially removed. Upon pathologic study the tumor was diagnosed as chordoma.

The patient left the hospital with improvement of symptoms. One year later he was admitted again for study. During the interval the tumor had increased in size gradually and there was return of

symptoms of difficult defecation and urination. Dull pain over both lower extremities had been present for about six months. Another roentgenologic examination showed changes similar to these present before, except that the sacrum appeared more expanded. Findings of expansion, rarefaction, and trabeculation were also found in the blade of the left ilium, indicating extension of the tumor.[1]

Case 3. A Chinese woman, 51 years of age, was seen on Aug. 1, 1933, because of pain in the sacral region, especially at night. The pain had been present for about two years and constipation for three months. Rectal examination revealed a large, smooth, round, firm mass measuring about 9 cm. posterior to the rectum. The sacral region was swollen and tender. The patient could not lie flat on her back.

Roentgenologic examination of the pelvis (Figs. 7 and 8) demonstrated moderate expansion and marked destruction of the middle and lower thirds of the sacrum. The involved area presented a lobulated appearance. There were irregular, soft, dense masses in the tumor. The outline of the growth was ill defined laterally, while its upper border was quite well limited by the uninvolved upper segments of the sacrum. With barium enema, the rectum was found to be compressed and displaced to the left side and anteriorly (Fig. 9). The roentgenologic diagnosis was malignant neoplasm in the sacrum and coccyx, suggestive of chordoma. Subsequent x-ray examinations in November and December, 1933, and in February and May, 1934, showed little change in the roentgenographic appearance of the sacrum and the tumor. In April, 1935, another examination revealed an extension of the sacral involvement and suggestive evidence of pulmonary metastasis.

A needle biopsy was done, obtaining some glistening semi-gelatinous material which, on microscopic study, was diagnosed as chordoma (Fig. 10).

The patient received two series of x-ray treatments (180 kv. constant potential, 8 ma., 50 cm. S.T.D., filters 56 mm. oil, 0.5 mm. Cu and 2 mm. Al, 20 r/min., 800 r measured in air, 100 per cent E.S.D.) from Aug. 23 to Sept. 20, 1933, and from Nov. 4 to Nov. 28, 1933, through two posterior and one perineal portals. The skin of each of the posterior portals received a total dose of 2,800 r and the perineal portal a total of 1,050 r. On Jan. 20, 1934, 28 radon gold seeds containing 51.66 millicuries were inserted interstitially in the tumor

[1] Case reported by Pai with complete pathologic study (18).

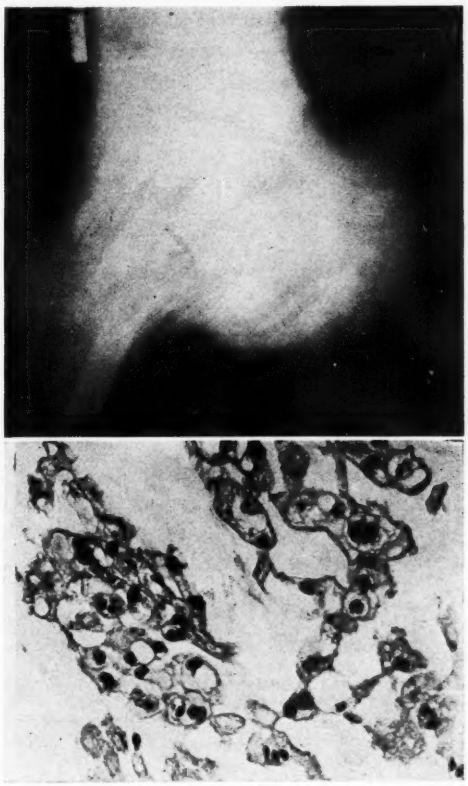

Fig. 5 (*upper*). Case 1. Roentgenogram of the sacral tumor in the lateral view showing the destruction of the lower two-thirds of the sacrum and the structural appearance of the dense trabeculæ and irregular masses in the protruding soft tissue tumor.

Fig. 6 (*lower*). Case 1. Photomicrograph showing masses of swollen vacuolated cells with intracellular mucin and intercellular free masses of mucin deposits. Elsewhere in the section not shown in this illustration the periphery of some of the masses is surrounded by a zone of cells with elongated nuclei, the so-called "sheath cells."

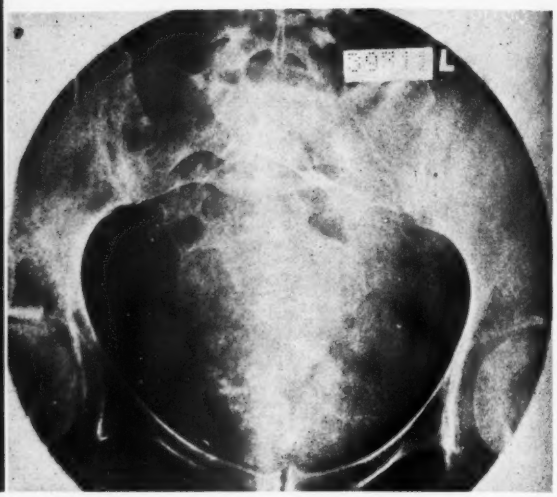

Fig. 7. Fig. 8.

Fig. 7. Case 3. Roentgenogram of the sacral region in the lateral projection showing marked destruction and expansion of the lower two-thirds of the sacrum. The outline of the end of the sacrum is entirely lost. The destroyed bone is traversed by dense trabeculæ and presents a lobulated appearance. Anterior to the sacrum in the tumor there are irregular masses of dense material.

Fig. 8. Case 3. Anteroposterior view of the sacrum showing destruction of the bone with the presence of trabeculation and vacuolation. The upper border of the involvement is quite well defined. The outline of the bone at the lower portions cannot be made out. Dense masses are seen in the left lower area of the sacral region.

and left in permanently; these delivered a total dose of 6,888 millicurie-hours. Following the x-ray and radon treatments, clinical examinations showed definite regression in the size of the tumor, marked relief of the difficulty in defecation, and practically disappearance of pain in the sacral and rectal regions. The patient disappeared from the clinic after a visit in May, 1934, and did not return until April, 1935, when a follow-up x-ray examination showed marked extension of the tumor into the upper third of the sacrum. Two months later there was increased difficulty in emptying of the bowels and bladder; more pain was present locally in the tumor and radiating to both thighs. Further radiation therapy was advised, but refused by the patient.

ROENTGENOLOGIC CONSIDERATION

From the review of the literature, it seems to be that chordoma in the spheno-occipital and thoraco-lumbar regions does not yield positive roentgenologic diagnostic signs except for destruction of the bone and compression of the spinal cord as shown by injected contrast medium. The destruction and compression have no intrinsic characteristic appearance. However, in Hass' case of spheno-occipital chordoma, Sosman thought that if metastatic tumor could be ruled out, the location alone would favor the diagnosis of a primary chordoma, and in Andler's case of hypophyseal chordoma roentgenologic changes characteristic of sacrococcygeal chordoma were found.

In chordoma of the sacrococcygeal region, the study of our own cases and those reported in the literature has led us to believe that there are characteristic roentgen signs. These signs are as follows:

1. *Expansion.*—This may be demonstrated in the anteroposterior or lateral views, preferably by stereoscopic examina-

tion. The bone is hollowed out and appears widened in one or more diameters. The outline of the bone may or may not be entirely preserved.

2. *Rarefaction or Destruction.*—The involved bone presents either a loculated appearance with multiple small circular or oval radiotranslucent areas or the bone is destroyed in large areas.

3. *Trabeculation.*—The remains of the undestroyed bone form dense trabeculæ which may extend into the soft tissue mass outside the original normal boundary of the bone.

4. *Calcification.*—This may be due to reactive new bone formation or deposit of calcified material in the tumor as a result of degeneration or necrosis. This calcified matter appears usually in irregular masses of soft radio-opacity.

In our three cases all or most of these signs are present. In the articles by Andler (4), Halter (14), and Wildbolz (17), in which roentgenograms are reproduced (Figs. 1, 2, and 3), the roentgenologic appearance of the changes is strikingly similar to that of our cases. Even in Case 7 of Fletcher, Woltman, and Adson's report (8), which is the only case illustrated by a roentgenogram, the appearance of the involved sacrum seems to show the same findings, *i.e.*, expansion of the bone, loculation, and trabeculation. Andler's description of the roentgenologic findings of his cases (4), which he believed to be typical of chordoma, agree in general with ours.

In order to understand the roentgenologic appearance of chordoma in the sacrococcygeal region a review of the gross anatomic appearance of the tumor is helpful. The typical chordoma is a slowly infiltrative, expanding growth, usually well encapsulated by fibrous tissue which is continuous with the narrow septum of connective tissue that divides the tumor into irregular lobules. These lobules are composed of soft, mucinous or gelatinous tissue, which is semitransparent or translucent. The softer portions are pale bluish-gray, while the firm opaque lobules usually indicate a more rapid rate of growth, increased

Fig. 9 (*upper*). Case 3. Lateral view of the pelvis after barium enema, showing anterior displacement of the rectum due to the tumor arising from the sacrum.

Fig. 10 (*lower*). Case 3. Photomicrograph of the tumor showing tumor cells with small and large vacuoles. There is no clear-cut cell border. Among the cells a large amount of homogeneous mucinous matrix is present.

cellularity and a heightened tendency toward the invasion of regional tissues. Foci of necrosis with hemorrhage are not uncommon. Cystic degeneration with calcification is infrequent. Bits of cartilage, clumps of sequestrated bone, and islands of newly formed bone are observed in some instances, especially in regions in which the neoplasm is in contact with bone. The invasion of bone is characterized by irregular lacunar resorption, and reactive osteogenesis is never prominent. The widespread infiltration of soft tissues is rare. From

this description of the pathologic anatomy[2] one can understand the formation of the roentgenologic findings of expansion and multiloculated areas of rarefaction or destruction of the bone, dense trabeculation and occasionally irregular calcified masses in the soft tissue tumor.

It must be admitted that these roentgenologic findings are not pathognomonic of chordoma in the sacrococcygeal region. In fact, such findings elsewhere in the skeleton may indicate giant-cell tumor, osteochondroma, or myxochondroma, but the clinical picture and particularly the sacrococcygeal location of the lesion should suggest the diagnosis of chordoma. Giant-cell tumor and chondroma occur in younger individuals and their occurrence in the sacrococcygeal region is extremely rare. However, biopsy should always be relied upon to obtain the final diagnosis. It should also be mentioned that the roentgenologic findings for sacrococcygeal chordoma as described above are not present in case the tumor is mainly of ante-sacral or post-sacral origin without infiltration into the sacrum. When the sacrum is involved in such a case, the findings in the bone are likely to be those of pressure and secondary changes, as in the case of a very large chordoma reported by Willis (19), which apparently arose from the anterior surface of the sacrum and extended down into the upper part of the thigh and yet showed no marked involvement of the sacrum.

SUMMARY

1. The literature on the roentgenologic diagnosis of chordoma, especially in the sacrococcygeal region, was reviewed.

2. Three cases of sacrococcygeal chordoma, with roentgenologic examination, were reported.

3. Three cases and those reported by others were studied from the roentgenologic standpoint. Certain findings found in the three cases of our series and in many of the others are described; they are considered as characteristic of chordoma in the sacrococcygeal region.

[2] An abstract from Hass' article (6).

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EDITORIAL

LEON J. MENVILLE, M.D., *Editor* HOWARD P. DOUB, M.D., *Associate Editor*

RADIATION DOSAGE

Often in medical meetings, especially when cases are presented before a general gathering of men who are not radiation therapists, such a statement as the following is heard: "This case had a test of radiation therapy." The remark, as it stands, is worthless, yet any attempts to persuade the speaker to give definite data as to the amount of radiation used are apt to elicit either a vague answer or a definite admission of ignorance on the subject.

Why should we tolerate vagueness in regard to radiation dosages? Certainly we do not suffer it in reports on drug dosages. It is almost impossible to imagine that a physician, in reporting a heart case in which digitalis had been administered, would fail to state the exact amount of the drug used. It is still harder to imagine that his audience would let the omission slip by without remark.

Even after the amount of radiation has been stated, the story is but half told, as a radiologist knows. The technic of administration must also be known if we are to get a worthwhile picture of the case. Negligence on this point would be held an egregious error in a report on the use of digitalis in a heart case. Why is it not so regarded in radiation therapy?

To report radiation treatment and omit the dose is a waste of time—not only the time of the audience or readers, as the case may be—but of the many scientists, past and present, who have spent their time and energy in working out measurements for radiation dosages, not to mention the physician who prescribed the treatment.

Another unfortunate tendency of speakers unversed in radiation therapy is to use loosely the terms "radiosensitive" and "radioresistant." To be of any use at all, these terms must be modified. To say that a cancer is radiosensitive is as valueless, *per se*, as to say that it is large. If the latter adjective were used, the immediate question would be, "How large?" The question, "How radiosensitive?" is an equally justifiable and necessary response, in view of the fact that recent results have demonstrated "radiosensitive" and "radioresistant" to be purely relative words.

A careless disregard of knowledge which has been painstakingly—and often painfully—gained is almost as great a misdemeanor as the oldtime custom of persecuting any one who advanced an original idea in science. In a way, it is worse, because it is more insidiously destructive. It is often the case that a technical term, as used by laymen, comes to have such broadness and indefiniteness of meaning that the technician or professional man himself subsequently discovers the necessity for redefining the term each time he uses it in order to bring it back to its true, well-limited sense.

JOHN T. MURPHY, M.D.

COMMUNICATIONS

May 28, 1936

DR. LEON J. MENVILLE, *Editor*
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"To the Editor:

"The increasing interest shown in roentgenkymography makes it necessary now at the outset that basic facts regarding this method be clearly established. For this reason and others, I am moved to comment on certain sins of commission and omission in the article published by Scott and Moore in the May issue of RADIOLOGY.

"The article states: 'Hirsch reported on the requirements of a proper kymograph but did not describe its construction.' It cannot be that, having read with great assiduity and assimilated thoroughly the article in the British Journal of Radiology, so generously referred to, they have ignored or forgotten the two contributions published in RADIOLOGY.

"The paper of Hirsch in the April, 1934, RADIOLOGY, Vol. 22, represents the first discussion of the construction, operation, and application of modern kymography published in this country. In this article, on page 405,

Hirsch states, speaking of the kymograph, 'The arrangement is essentially a grid diaphragm mechanism with the springs removed. In place of the grid there is mounted a carriage to hold a 14 × 17 cassette. This is mounted vertically, so that when released, the film falls by its own weight. On the front of the frame, between patient and film, there is mounted a lead grid consisting of slits 0.4 mm. wide, spaced at a distance of 12 mm. from each other. The grid-diaphragm contactors have been so rebuilt that the exposure can be adjusted by means of a speed control. A time marker record, in fifths of a second, is impressed on the film during its exposure.' There then follows a description of the use of the time marker.

"A careful study of Scott and Moore's paper fails to reveal anything novel either in the construction or application of the kymogram. The use of the Bucky mechanism for the foundation of the apparatus is certainly not new and the description of the apparatus by Hirsch is as detailed as that given by Scott and Moore.

"It is true that Hirsch's article contains no picture of the Potter-Bucky diaphragm apparatus, which serves only as the mechanism for moving the grid. It is certainly true (see preface 'The Principles and Practice of Roentgen Therapy,' by Hirsch, 1925), as the Chinese say, a picture is better than a thousand words, but why clutter up our Journal with useless pictures or, for that matter, useless words?

"Further, even for two years before the publication of this first article, we have shown to those to whom our work was exhibited before its publication, and in numerous instances since, by word and letter, details of the construction of our apparatus indicating the simple way of modifying the Potter-Bucky diaphragm to make the kymograph.

"Dr. Scott and Dr. Moore accept the 0.4 mm. grid and 12 mm. spacing in naïve simplicity as if it were obtained as a gift from God. If they will take the trouble to study Table I (page 405) of the article above referred to, they will find that 0.4 mm. slit, 12 mm. spacing, and one second exposure was first used by us, yet in their article no credit is given for this, although it is a contribution of no little importance. The determination of the optimum slit width and spacing represents considerable preliminary work and much thought and experiment.

"They apparently do not appreciate that the most important part of the apparatus is not the mechanism of the Potter-Bucky diaphragm outfit by which the film or grid is made to move, but the slit width and its spacing. It is this which, giving a wave form of considerable extension, rich in detail and superior to any wave form previously inscribed by any other arrangement, permitted us to analyze and discuss the significance of the serrations associated with valve closure and heart sounds (Acta Radiologica, Vol. XV, Fasc. 2, No. 84).

"Scott and Moore, in their listing of the requirements for an ideal kymograph, have written what amounts to an excellent summary of material published by Hirsch. All the requirements except three are included in Hirsch's listing in the British Journal of Radiology, Vol. VII, December, 1934. Of the three exceptions, one (No. 3) must be objected to on grounds discussed in the next paragraph; one (No. 8) represents an experiment which has been discarded by us years ago as unimportant, and one (No. 11) is only of partial value, since the more important source of motion is the breathing of the subject, and an immobilization band can scarcely be intended to inhibit respiration.

"Scott and Moore's suggestion embodied in point No. 3 is of questionable value. For very fast motions it is, of course, possible to diminish the size of the slit spacing and still preserve the record of complete cycles. But is there any value in making records of points closer together than 12 mm.? On the other hand, in the gastro-intestinal tract, for example, the conditions necessary for recording a full cycle may justify the use (with the 0.4 mm. slit) of greater slit spacings. However, does the difference between 12 and 18 mm. length of record justify the added complication? Is not a spacing 18 mm. getting dangerously large, since important lesions of the tract may themselves have an extent no larger than this?

"Further, the use of the multiple slit method was not first advanced by Stumpf, but by an American, Sam Katzman ('The Roentgen-ray Cardiograph,' RADIOLOGY, 1930, **8**, 134–140), which device, though published then, had actually been completed and utilized some years previously. The numerous spaced slits were embodied in the apparatus he described, though the manner of movement of the film was different from that used in the present-day apparatus.

"Finally a word as to the kymoscope. This has not been stressed by Hirsch anywhere in

his writings because it is unimportant and of no value in advancing the application of roentgen kymography. True, it is always warranted to 'èpater le burgeois,' and mildly amuse the uninitiated, but why waste time with this plaything when the wave cries out for analysis? There are many secrets awaiting disclosure in the kymographic wave; why not concentrate on its study?

"Cinematizing the kymoscopic illusion gives, at best, only a faked movie. Surely, if it is desired to demonstrate the movements of the thoracic viscera—lungs, heart, diaphragm—the present, entirely feasible method of cinematizing the fluoroscopic image, according to the method of Reynolds, is far more preferable, desirable, and accurate."

Yours truly,

MYRON SCHWARZSCHILD

Dept. of Radiology
New York University
School of Medicine

June 18, 1936

DR. LEON J. MENVILLE
Editor of RADIOLOGY
1201 Maison Blanche Building
New Orleans, La.

"My dear Dr. Menville:

"We thank you very much for the opportunity which you afforded us to read Dr. Schwarzschild's letter of May 28 and for giving us the opportunity to reply to it.

"One of us (S. M.) has enjoyed the friendship of Dr. I. Seth Hirsch for many years and holds his scientific achievements in highest regard. Because of this, anything which even remotely suggests that due appreciation of his contributions to roentgen kymography has not been given is particularly regrettable.

"The sole purpose of the paper, "The Construction of Roentgen Kymographs and Kymoscopes," was to present our experiences in the design and use of the roentgen kymograph and kymoscope in order to popularize what we believe to be an invaluable aid in the study of many pathological conditions. We advanced no claims to originality or innovations in the development of either the kymograph or the kymoscope. To read anything else into our paper is to introduce something entirely foreign to our intention. Under no circumstances do we wish to omit, detract from, or discredit any of Hirsch's work on kymography. It should be well known to all interested in the subject that Hirsch introduced the modern kymograph (Stumpf's) to the medical profession of this country. We acknowledge and assume full responsibility for our failure to refer to Hirsch's articles published in RADIOLOGY, Vol. 22, No. 4, pp. 403–422, April, 1934, and Vol. 23, No. 6, pp. 720–737, December, 1934, reprints of which he kindly gave us. We also fully acknowledge "assiduous assimilation" of Hirsch's article, "The Examination of the Heart by the Roentgenkymographic Method," British Journal of Radiology, New Series, 1934, Vol. 7, pp. 728–754. Our exhibit at the Twenty-first Annual Meeting of the Radiological Society of North America fully credited Hirsch and carried the above references.

"We are not convinced that Hirsch's description of the construction of the kymograph is as detailed as ours. In our opinion, the description which we gave of the requirements for a suitable kymograph is more detailed than Hirsch's and more clearly presented than his summary in the British Journal of Radiology. We made reference to and acknowledgment of this article.

"The 12 mm. grid spacing has been the standard used by Stumpf since 1931. ('Das Röntgenographische Bewegungsbild und Seine Anwendung,' Fortschritte auf dem Gebiete der Röntgenstrahlen (Erganzungsband), 1931, **41**, 15). However, the slit width used by Stumpf was 0.5 mm. as compared with 0.4 mm. advocated by Hirsch. As stated in our article, our first grid was 0.4 mm. wide. We believe that a slight variation in the width of the slits is of theoretical rather than practical import. The superior detail of the waves shown by Hirsch and associate is to be explained by his exposure time of one second rather than by the width of the slit. We acknowledge this fact as an advance in the subject. The German kymographs commercially available in 1931 had an adjustable exposure timer varying from one to 60 seconds. A set standard for the exposure time for all individuals is impractical. The exposure time should be varied with the heart rate. With a grid spacing of either 0.4 mm. or 0.5 mm., the increase in detail will be due principally to a short exposure which permits one cardiac cycle to be recorded on a single frame of the kymogram.

"We agree with Dr. Schwarzschild that the Potter-Bucky mechanism for moving the film is not the essence of a good kymograph but only a means of producing a uniform speed of

motion. This is essential for avoiding distortion of the waves. The desirability of using interchangeable grids of 6, 12, and 18 mm. is purely a matter of personal opinion and experience. We have found that the 18 mm. grid is superior to the 12 mm. grid for recording the relatively slow movements of the thorax and its contents during respiration. The 6 mm. grid has proved to be of value in studying the movements of various joints and in recording the rapid movements of deglutition. It is possible that the 18 mm. grid may not be the ideal one for gastro-intestinal use, but this can be determined only by further work.

"We do not agree that a device for making a time record on the kymogram is unimportant (as stated by Dr. Schwarzschild in paragraph 9), because in cardiac kymography we vary the exposure according to the pulse rate and consequently more frequently record a single cardiac cycle in a frame than would be the case if the timer were omitted. With the time record inscribed on the film, the pulse rate can be accurately read from it as can the duration of various other movements.

"The literature has been read again and it confirms our belief that Stumpf has priority in the use of the multiple slit grid for kymography. He presented his work at the Second International Radiological Congress in Stockholm in July, 1928 ('Die Gestaltanderung des schlagenden Herzens im Röntgenbild,' Fortschritte auf dem Gebiete der Röntgenstrahlen, December, 1928, **38,** 1055–1067). However, Sam Katzman (A. I. E. E., Student Member), described his kymograph in August, 1928 ('The Roentgen-ray Cardiograph,' RADIOLOGY, August, 1928, Vol. 11, pp. 134–140.) Comparison of the illustrations of these two authors shows that Stumpf's apparatus is considerably more advanced than Katzman's. Because of this, and Stumpf's subsequent elaboration of the apparatus, we feel that undoubtedly he should be given credit for the development of the modern multiple slit kymograph. It is a curious fact that Dr. Schwarzschild did not mention Katzman in any of his articles except to list him in the bibliography which was alphabetically arranged, and yet he urges Katzman's priority now.

"As to the kymoscope, we need only repeat our previous statement that the kymoscope is not necessary for the interpretation of the kymogram. In fact, the kymogram can be far more profitably used by measuring the amplitude and studying the other characteristics of the waves. At the present time it is superficial to dismiss the kymoscope as a pretty toy with which to confuse the uninformed. Its utility in the classroom is so obvious that comment should not be required. A word as to the relative value of cinematizing the kymoscopic image and that of the fluoroscopic screen: to claim superiority for the latter is to overlook the fact that the screen represents the mean value of the incident energy, on the one hand, and the mean value of the fluorescence, on the other. Indeed, it seems to the writers that the kymogram itself indisputably establishes the fact that the fluoroscopic is the illusive and the kymoscopic image the true reproduction of that which actually takes place.

"We are concerned chiefly in this communication with accuracy in reference to the work of others. Therefore attention may be called to the following: Dr. Hirsch, in his brief historical sketch on kymography (RADIOLOGY, April, 1934, **22,** 404), dates Sabat's original work as appearing in 1913. It actually appeared in 1911, and it was republished in 1913, because Gött and Rosenthal did not acknowledge this reference. (Sabat, B., Polnischen med. Wchnschr., 'Lwowski Tygodnik lekarski.' Nr. 28, July, 1911. Republished in Fortschritte auf dem Gebiete der Röntgenstrahlen, 1913, **20,** pp. 42–44.) Likewise, Gött and Rosenthal are quoted by Hirsch as presenting their work in 1913 although their paper appeared in September, 1912. (Gött, Theodor, and Rosenthal, Joseph, Münchener medizinischen Wochneschrift, Vol. 59, pp. 2033–2035, September, 1912.) Knox, in his address before the Royal Society of Medicine, described his work on kymography in October, 1922. (Knox, Robert, 'Cardiac Diagnosis: A Survey of the Development of Physical Methods,' President's Address, Royal Society of Medicine Proceedings, 16, Parts 1 and 2, 1922–23, Section on Electrotherapeutics. pp. 1–30.) Dr. Hirsch dates his work in 1929. Stumpf's first report on kymography appeared in 1928. ('Die Gestaltanderung des schlagenden Herzens im Röntgenbild,' Fortschritte auf dem Gebiete der Röntgenstrahlen, 1928, **38,** 1055–1067.) Hirsch gives the date as 1929.

"We commend Dr. Schwarzschild for his keen interest in bibliographical accuracy and have made our own contribution to this end above. Some measure of the difficulty encountered in accurate reference can be gained

from the following: Dr. Schwarzschild, in his third from the last paragraph, refers to the article by Sam Katzman, 'RADIOLOGY, 1930, 8, 134–140.' The correct reference is: Katzman, Sam, The Roentgen-ray Cardiograph, RADIOLOGY, Vol. 11, pp. 134–140, published August, 1928."

Very truly yours,
WENDELL G. SCOTT, M.D.
SHERWOOD MOORE, M.D.

CONNECTICUT STATE MEDICAL SOCIETY

SECTION ON RADIOLOGY

The Connecticut State Medical Society held its one hundred and forty-fourth annual meeting at Hartford, May 20–21.

The program of the Section on Radiology was as follows:

"Results of Comparative Doses on Human Tumors Using Fever and Roentgen Radiation" (illustrated), by Stafford L. Warren, M.D., Associate Professor of Radiology, University of Rochester, N. Y. (*by invitation*).

Discussion opened by William S. Stone, M.D., Westport, and George T. Pack, M.D., New York City (*by invitation*)

"Roentgenologic Study of the Appendix" (illustrated) by Hugh Wilson, M.D., Assistant Professor of Radiology, Yale University School of Medicine, New Haven (*by invitation*).

Discussion opened by Ralph T. Ogden, M.D., Hartford.

At the business meeting which followed the program the following officers were elected for the coming term: R. H. Lockhart, M.D., Bridgeport, *Chairman;* Max Climan, M.D., Hartford, *Secretary-Treasurer.*

THE X-RAY IN INDUSTRY

A new chemical and metallurgical testing and production control laboratory which is one of the most modern industrial laboratories in the United States has been placed in service at a large manufacturing plant. The laboratory is another unit of the company's expansion and modernization program.

Completely air-conditioned and furnished with new x-ray, physical testing, and chemical analysis equipment, the laboratory is now working on a 24-hour-day basis. It is used to analyze the molecular structure of steels, to determine the physical properties of metals and fabricated parts, and to analyze steels, irons, and other metals; textiles, paints, oils, and rubbers used in the factory.

Included in the equipment is a new x-ray machine having an oil-cooled fine focus radiographic tube of 230,000-volt capacity. It has sufficient intensity to penetrate four inches of steel, and through its use flaws less than 2 per cent of total thickness are detected. Its intensity permits a great time-saving in making x-ray photographs—a crankshaft, for example, being photographed in about three minutes. To protect the operators from the rays of the machine, it is housed in a lead-walled room, and the operator watches the machine in operation through a safety lead glass.

The x-ray department also includes a diffraction machine equipped with a new tube which will obtain in 20 minutes films which formerly required from 24 to 70 hours of exposure. The machines are used largely in research to improve casting and steel-treating technic through a study of the atomic structure of the finished steels and alloys.

Another new instrument in the laboratories is the profilograph, the third one of its kind to be constructed, designed at the University of Michigan. It is used to examine steel finishes. Through an optical magnifying system, any imperfections in the finish which are detected by a diamond point are magnified 2,000 times vertically and 64 times horizontally. Thus the graph of a surface of a one-eighth inch specimen of steel becomes a readable chart eight inches long, with minute irregularities showing as deep ridges.

Well-equipped developing and printing rooms adjoin the x-ray and metallographic rooms. In these rooms also are miniature molding presses used to mount the metal specimen in bakelite for easy handling. The microscope used in the metallographic studies magnifies over 1,000 diameters, revealing the structure of a cross-section of steel.

In the physical testing rooms, various parts of machinery are subjected to heavy blows, twisting tests, and compression tests to determine their resistance and strength. In this department, two new hydraulic machines have been added to the equipment, one, a 100,000-pound machine, and the other a light weight machine permitting greater accuracy in testing light parts, such as fabricated gears.

In the analytical laboratory, all work tables are of stainless nickel-chrome-steel, and fur-

naces and other apparatus are of the latest improved type. At the end of the room is a specially constructed salt spray cell, where plated parts are subjected to salt baths. The laboratory throughout is lighted by an improved "daylight" system with batteries of five special bulbs providing a light as nearly equivalent to daylight as illumination engineers have been able to devise.

The laboratory is manned by a staff of 65 technicians, working in shifts. Since an analysis is made of every cast of metal from the blast furnaces, some part of the staff is on duty twenty-four hours a day, keeping an accurate check on the materials used in the factory.

BOOK REVIEW

RADIUMDOSIMETRIE VERFAHREN UND BISHERIGE ERGEBNISSE. By DR. KARL G. ZIMMER. Monograph, Fortschr. a. d. Geb. d. Röntgenstrahlen, 1936, Vol. 49, 40 pages, 33 illustrations. Published by Georg Thieme, Rossplatz 12, Leipzig C 1, Germany. Price RM. 6.50.

This monograph is an admirable compilation of recent advances in physics in the measurement of gamma rays. The discussion is quite technical and perhaps more intelligible to physicists than to physicians; however, Dr. Zimmer makes a point of mentioning the types of measuring instruments which are less complicated and may be used profitably by the practising physician.

The subject of radium dosimetry is divided into two large fields: (1) relative dosimetry, including the spatial distribution of radiation in the neighborhood of radium preparations and the best arrangements of single sources of applicators, and (2) absolute dosimetry which deals with the selection of a unit of radium dosage and its practicability.

In regard to relative dosimetry the author describes the recent instruments in this field with special reference to the Radium-Hammer dosimeter of Pychlau. Other recently developed instruments are also discussed. The photographic method of measurement of Holthusen and Hamann is reviewed, and this is followed by an analysis of biological methods such as the use of *Drosophila* eggs. The mathematical method of calculation is then portrayed with tables calculating the dosage delivered from needles or tubes, and a diagram showing the intensity of irradiation from plaques. Finally, relative dosimetry is concluded with a comparative discussion of the above-mentioned methods.

In regard to absolute dosimetry, the author states that the question of a suitable unit of gamma-ray dosage can be taken as settled since the majority of authors accept the roentgen (r) unit. He discusses the difficulties of measurement of gamma rays with a large chamber and the advantages of the air-walled small chamber. He maintains that for practical measurement in r units, the important points are adequate wall thickness of the chamber, and for measurements in scattering media, wave length independence of the chamber.

A section is devoted to special problems of dosage with radium bombs and measurements of dosage are quoted. There is discussion regarding the measures necessary for protection of radium workers.

The author points out that very little work has been done to date regarding dosage with alpha and beta rays, although beta rays possess considerable importance in treatment.

The work is well illustrated with tables and charts showing the best arrangement of radium applicators for equal distribution of irradiation. There are several excellent tables and charts showing depth dosage with various filters and applicators. A very good bibliography is appended.

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LUNGS

The Lower Lung Line. Ephraim Korol. Am. Jour. Roentgenol. and Rad. Ther., December, 1935, **34,** 740–743.

In films of the upper abdomen there may be seen a horizontal line running from the lateral chest wall toward the first lumbar vertebra on each side. This line, referred to as the lower lung line, represents the lower posterior pleural boundary, *i.e.*, the fold of parietal pleura reflected from the posterior chest wall onto the diaphragm. This line may be followed into its junction with the line representing the posterior mediastinal pleural fold.

Occasionally the lower anterior pleural fold may also appear as a horizontal line at a slightly higher level than the posterior lung line. The anterior line has been seen only in cases of emphysema; it can be traced on the film into the pericardio-pleural fold.

In cases of emphysema and visceroptosis, also in cases of pneumothorax, the lower lung lines often appear in the chest roentgenograms as horizontal lines crossing the twelfth rib a short distance below the dome of the diaphragm which is flattened and placed low in these cases, and may be mistaken for pleural fluid.

In cases of atelectasis or fibrosis of one lobe with compensatory emphysema of the healthy lobes, the lower lung line often shows on the routine chest roentgenogram due to ballooning of the pleural fold by the emphysematous lung.

S. M. Atkins, M.D.

PEPTIC ULCER

The Importance of the Anteroposterior Film of the Duodenal Bulb for the Exact Localization of Duodenal Ulcer. B. A. Fanardjian. Röntgenpraxis, December, 1935, **7,** 806–813.

It is of considerable importance to localize a duodenal ulcer, especially for the surgeon. The roentgenologic demonstration of a niche is not always possible on oblique views due to anatomical variations. It is possible, according to the author, to predict the exact situation (anterior or posterior wall) on the anteroposterior film. The rules applicable for this relationship are as follows: (1) If there is a defect on the lateral contour of the cap on the anteroposterior film, the niche can be shown on the anterior wall; (2) if the defect is seen on the medial contour of the cap on the anteroposterior view, the niche can be demonstrated on the posterior wall, and (3) if the defect is seen on the medial as well as on the lateral contour of the cap on the anteroposterior view, the niche can be demonstrated on the anterior as well as on the posterior wall ("kissing ulcers").

This relationship is almost a law and has, heretofore, not been used enough by the radiologist. The author has proven his contention in several hundred ulcer patients. Only in complicated cases might there be deviations from the above rules.

Hans W. Hefke, M.D.

PNEUMOTHORAX

Indications for Collapse Therapy. A. Heymer. München. med. Wchnschr., Jan. 17, 1936, **83,** 101–105.

Artificial pneumothorax is effective in pulmonary tuberculosis, by mechanically resting the affected lung, producing passive congestion and lymph stasis, causing retraction and collapse of cavities, and diminishing the absorption of toxic products. The most important consideration is the type, rather than degree of involvement; thus, a purely exudative lesion, even though of relatively small extent, is actually made worse by collapse therapy. This is due to the non-compressibility of the diseased area owing to the exudate, and the causation of overwork of the normal pulmonic structure to compensate the diminished space, which, in turn, produces a marked exacerbation of general symptoms, by increased absorption of expressed toxic material. If there is no reasonable outlook or definable evidence of resisting contiguous pulmonary tissue, then collapse therapy should not be employed. It is patent that the most favorable cases are those of the fibrotic and fibroulcerative type, with or without cavitation. A diagnosis of the pure exudative type can be made only by correlation of clinical symptoms and signs of activity with roentgenologic evidence and hematologic study.

It is imperative to establish the presence or absence of tubercle bacilli, by assiduously examining the sputum, by culture, smear, and guinea pig inoculation; also, examination of gastric contents and laryngeal smear. Repeated negative findings indicate conservative treatment as being adequate. One exception is the presence of pulmonary tuberculosis of a mother with children as potential contacts, for in such a circumstance, collapse therapy is strongly urged.

It has been found that the prognosis is far better in the lower social strata; *viz.*, factory workers, in whom collapse therapy has been instituted, together with added benefit of rest and good nourishment. One great advantage of collapse therapy is that it is not an irreversible procedure, as are other operative procedures. Other contra-indications to collapse therapy are: bronchial asthma, marked pulmonary emphysema, and cardiac weakness only when decompensation is present. No age limit has been found. Pregnancy and diabetes controllable by insulin are not contra-indications. If other organs are involved, the decision rests upon the severity of involvement of the former. Thus, laryngeal tuberculosis is generally benefited. Unilateral renal tuberculosis is a strong indication, whereas bilateral involvement contra-indicates radical collapse therapy. It should be remembered that tubercle bacilli can be filtered through a normal kidney, and their presence do not necessarily mean parenchymal involvement. Extensive bilateral pulmonary tuberculosis producing dyspnea is an apparent contra-indication for artificial pneumothorax. Other surgical methods such as thoracoplasty, *plombe*, and phrenico-exeresis should be employed when artificial pneumothorax is mechanically not feasible; *viz.*, pleural adhesions, markedly thickened pleuræ, and the like.

William R. Stecher, M.D.

Spontaneous Pneumothorax. E. Schott. München. med. Wchnschr., Nov. 1, 1935, **82,** 1751–1756.

The pathogenesis is briefly considered, and although the author favors the theory of ruptured emphysematous blebs or bullæ, nonetheless none of these could be roentgenographically demonstrated after reinflation of the lung. The possibility of tuberculosis or so-called "congenitally weak pleura" is considered as etiologic factors. In practically all cases observed, there was a concomitant pleural effusion, and its presence is considered as favorable to healing of ruptured pleura. The differential diagnosis must be made between true pulmonary abscess and encapsulated hydropneumothorax, a distinction which is readily accomplished roentgenographically.

Injection of dextrose solution into the pleural cavity aided the healing and reinflation of the collapsed lung.

WILLIAM R. STECHER, M.D.

RADIATION, PHYSICS OF

Registration of the Ionization Curve of a Single Alpha Particle. H. Alfvén. Zitschr. f. Physik, Nov. 25, 1935, **97,** 718–724. (Reprinted by permission from Science Abstracts, Sect. A, Physics, Jan. 25, 1936, **39,** 35.)

The track of ions which is produced by an α-particle moves in a homogeneous electric field with constant velocity. The whole ionic track can thus be brought progressively into a discharge chamber, where it produces a current which gives the ionization curve. The current which is of the order of magnitude 10^{-13} A is by a specially constructed amplifier so much amplified that it can be oscillographed. The oscillograms thus obtained give a good picture of the ionization curve. The method can perhaps be useful in the study of nuclear reactions. J. J. S.

Deflection of Alpha Particles. R. Mercier and P. Scherrer. Helv. Phys. Acta, 1935, **8,** 589, 590. (Reprinted by permission from Science Abstracts, Sect. A, Physics, Jan. 25, 1936, **39,** 35.)

A brief description of apparatus for demonstrating the deflection of α-particles by nuclei. W. E. P.

Radiotherapy (Roentgen Rays; Radium). Arthur U. Desjardins. Jour. Am. Med. Assn., Dec. 21, 1935, **105,** 2064; Dec. 28, 1935, **105,** 2153.

When cells of a given kind are exposed to a certain dose of radiation, some are destroyed, some are injured but regenerate later, and some do not show any deleterious effect. Such variation in the susceptibility of different cells of the same kind is probably due to the metabolic stage of the cells and perhaps to other unknown factors.

Whatever the main reason for variation in the radiosensitiveness of different cells of the same variety may be, this does not affect the fundamental law of the specific sensitiveness of different varieties of cells, a law based on innumerable experiments on animals and substantiated by extensive clinical observations.

Biologic considerations are discussed under a classification in the order of their degree of sensitiveness.

Under clinical radiotherapy the practical aspects of radium and roentgen rays are discussed as they apply to inflammatory diseases and tumors. Methods of application and also radiation sickness are included in the discussion.

CHARLES G. SUTHERLAND, M.B. (Tor.)

RADIUM

Recent Advances in Radium Therapy. H. S. Souttar. British Med. Jour., Feb. 29, 1936, No. 3,921, 401–404.

While it has been observed that as a general rule the cells of malignant tumors are destroyed more readily by radium therapy than normal cells, it is doubtful that this action is due to the individual sensitivity of the tumor cell but rather to biological characteristics of the tumor cell which render it more sensitive than the cells of most adult tissues. Malignant tumors grow more rapidly than normal tissues; therefore, the individual cells are constantly undergoing nuclear division and their chromatin is more vulnerable to radium therapy. Another factor which plays a part is that malignant tumor tissue is more embryonic and less highly developed than normal tissue.

The changes in connective tissue as a result of radium therapy is somewhat different from the effect of radium on cellular elements. These changes result from a slowly developed endarteritis accompanied by changes in the capillaries, affecting their permeability and the nutrition of the tissues they supply. Thus it is known that radium injures both the tumor cells and the tissue cells and the efficiency of radium therapy depends upon obtaining the maximum effect on the tumor cells with the minimum effect on connective tissue.

The ideal desired in this form of therapy is the thorough and uniform irradiation of the entire field. This should include all lymphatic areas probably involved as well as the primary field. Uniformity in irradiation therapy is obtained by the use of proper filtration to eliminate the softer rays.

It is necessary that the unit of radiation be accurately defined. While the r is considered the most ideal unit as it allows comparisons between x-rays and radium, the practical difficulties of measuring r are great. It has, therefore, been suggested that the "natural radium unit" be adopted. This unit is the amount of radiation delivered at a distance of one centimeter by one milligram of radium. However, this does not consider the effect of filtration. The author has suggested an appendix from which the dosage may be determined with due consideration to filtration.

The insertion of radium needles into the tissues is considered one of the most useful methods of application. Such needles provide constant sources of radiation of known value. The wall of the needle should not be less than 0.5 mm. of platinum in order that effective filtration may be obtained. The needles should be placed at the growing edge of the tumor and in such a manner that cross-fire may be obtained.

Radon seeds are small tubes of platinum or gold, in which are sealed up minute amounts of radium emanation. At first the effect is the same as with radium needles, but as time passes the emanation decays, so that at the end of a two weeks' period the action is negligible. The author has devised an introducer for the application of radon seeds which allows rapid introduction of these elements.

Another method of application of radium is the use of plaques and molds. This has the advantage of more uniform irradiation by increasing the distance from the surface. The arrangement of the radium on the plaques is determined by placing one-half of the radium on the surface of the plaque and the other half around the margins of the plaque. The amount of radium needed to give the required intensity at the surface may be determined by the author's instrument.

With larger amounts of radium, beam radiation is employed. Considerable research is going on at present with various forms of applicators, and the author has devised several units which allow the delivery of radium to the unit by pneumatic means after placing the unit in position. This eliminates the usual cumbersome, heavy unit without endangering the patient or attendants. A short-beam unit which makes use of smaller amounts of radium, and which because of its smaller size has a greater field of usefulness, has been devised by the author.

J. N. Ané, M.D.

Radium Dosage and Technic in Carcinoma of the Skin, with Special Reference to Interstitial Irradiation with Platinum Iridium Needles. H. N. Cole and J. R. Driver. Am. Jour. Roentgenol. and Rad. Ther., May, 1935, **33,** 682–689.

Prolonged interstitial irradiation with heavily filtered platinum iridium radium needles of small intensities is superior to other forms of therapy in the treatment of selected cases of skin malignancy. The authors use needles containing 1, 2, or 3 mg. of radium element and 27, 44, and 60 mm. in length. The radium is in cells 15 mm. in length, containing 1 mg. each of radium.

In small tumors, the needles are arranged parallel and in large tumors, radially. They are inserted through the normal skin and through or under the tumor under aseptic conditions and local anesthesia. The calculation of the dose is simple, for the needles are so constructed that they will destroy 1 c.c. of squamous-cell carcinoma per running centimeter of active radiating focus in seven days. Hence needles are placed 1 cm. apart and each cubic centimeter of tissue will receive 116 mg.-hr. in seven days, or 160 mg.-hr. if left 10 days. A biopsy is taken before or at the time treatment is instituted.

At the end of about one week the overlying skin becomes deep red or purple and on the tenth day vesiculation may be present, to be followed by exfoliation of the epidermis, exposing an adherent yellowish fibrous exudate. Healing requires from three to six weeks. The resulting scar after a few weeks is healthy and there is little or no deformity.

The indications for this type of treatment are: rapidly growing or advanced prickle-cell carcinoma, extensive basal or baso-squamous carcinoma, deeply growing types or types with scar tissue, malignancies over bony prominences in which bone may be involved, areas having underlying cartilage or fascia or dense integument, and recurrences.

The result of treating metastases by this method supplemented by external irradiation has usually been good.

S. M. Atkins, M.D.

Radium Dosage and Technic in Carcinoma of the Tongue. Frank E. Simpson. Am. Jour. Roentgenol. and Rad. Ther., July, 1935, **34,** 63–68.

Every carcinoma of the tongue, unless it is too extensive or shows metastases, should have implantation therapy. If every part of the tumor can be reached, a clinical cure often results.

The author employs lead antimony radon tubules which are left in place permanently and the dose is as large as the normal tissue can stand without serious injury. These are implanted by a syringe-like apparatus under local anesthesia. Biopsies are done by means of cutting forceps or scissors.

Treatment is not held up on account of month infections, which are not radically treated. Metastatic nodes are treated either by roentgen or radium bomb radiation.

S. M. Atkins, M.D.

Radium in the Treatment of Metastatic Epidermoid Carcinoma of the Cervical Lymph Nodes. Douglas Quick. Am. Jour. Roentgenol. and Rad. Ther., May, 1935, **33,** 677–681.

All cases of upper mucous membrane tract cancer acceptable for treatment receive roentgen therapy to both sides of the neck to a degree that produces an intense erythema at the end of two or three weeks, to be followed by scaling. Necks presenting no palpable glands receive no further treatment.

When glands are palpable, treatment varies. In the strictly anaplastic, and in the extremely advanced metastatic involvements, especially in cases in which the primary growth is far advanced regardless of the histologic type, roentgen therapy alone is the rule.

Surgical dissection is limited to cases that show fully differentiated epidermoid carcinoma, palpable involvement unilateral, capsule of the nodes intact if the patient's general condition is good and in whom primary growth is controlled or gives signs of future control. The dissection, however, must be most radical.

In all other types, interstitial irradiation therapy is employed following the initial roentgen therapy. The author prefers radon seeds implanted in the nodes, not through the skin but after exposure of them under local anesthesia. The dosage varies, but should always be carried to the limit of normal tissue tolerance.

The minimum is 3,000 mc.-hr. and maximum 10,000 mc.-hr. Nodes over from 5 to 7 cm. in diameter are the upper limit in size suitable for irradiation treatment. The recurrent node is not to be treated surgically even if the capsule is intact, but by implantation.

In fat necks, and in sites near the salivary glands, scar tissue, and nerves, the dose must be watched with care. Repetition of interstitial irradiation is contra-indicated. Syphilis has no bearing, but in the presence of infection in the neck or even in the mouth, this type of treatment is contra-indicated.

S. M. ATKINS, M.D.

Complications and Injuries in Radium Therapy. Ira I. Kaplan. Am. Jour. Roentgenol. and Rad. Ther., July, 1935, **34,** 77–80.

Radium therapy requires training, experience, and attention to the essential physical and biologic factors associated with it. Injuries following radium therapy are traceable to failure in diagnosis, mistakes in judgment, errors in technic and in the after-care of the patient. Radium injuries are in many instances due primarily to faulty technic and are most often preventable.

S. M. ATKINS, M.D.

Mutations Produced in the Fruit Fly by Alpha Particles Following Inhaling of Emanation. K. G. Zimmer and N. W. Timoféeff-Ressovsky. Strahlentherapie, 1936, **55,** 77.

Male fruit flies were placed in a vessel containing radium emanation. It was possible to produce mutations; further studies showed that they were due to the effect of alpha particles.

ERNST A. POHLE, M.D., Ph.D.

Long Freedom from Symptoms in a Carcinoma of the Esophagus Treated with Radium. S. Epstein. Strahlentherapie, 1936, **55,** 127.

The author observed a case of carcinoma of the esophagus (proved by biopsy) which responded well to repeated applications of radium. Heavily filtered screens were placed in the esophagus with a flexible sound. The patient died from acute nephritis four and one-half years after the treatment. While no autopsy was obtained, clinical symptoms suggested that several weeks before death a beginning recurrence was present in the esophagus.

ERNST A. POHLE, M.D., Ph.D.

Epithelioma of the Ear Lobe. S. Laborde and E. Via. Strahlentherapie, 1936, **55,** 114.

At the Cancer Institute of Paris the authors found that among 763 skin cancers seen since 1922 there were 59, or approximately 8 per cent, epitheliomas of the ear lobe. In nine cases no treatment could be given, either because of the extent of the lesion or refusal of the patient to enter the hospital. In six cases the tumor was removed by the endotherm knife, but the remaining cases were treated by radium. In small tumors, particularly in the edge of the helix, radium needles containing 2 mg. of radium and filtered through 0.5 mm. Pt were inserted and left for from three to seven days. In other cases, surface applicators consisting of 2, 5, or 10 mg. screens filtered through 1.5 mm. Pt were used, depending on the size and depth of the lesion. Extremely high doses are contra-indicated since they not only fail to produce a cure but apparently render the condition worse because of necrosis of the cartilage complicated by secondary infection. With more conservative doses the results have been very satisfactory. Photographs of a series of cases before and after treatment are appended.

ERNST A. POHLE, M.D., Ph.D.

A New Method in the Preparation of Highly Concentrated Radium Emanation Tubes. O. Werner. Strahlentherapie, 1936, **55,** 185.

The author briefly describes an emanation apparatus which he developed over a period of years. It permits the preparation of highly concentrated emanation tubes with an efficiency rate of about 80 per cent. A schematic drawing of the apparatus is shown with the article.

ERNST A. POHLE, M.D., Ph.D.

Absorption Coefficients of Hard Gamma Rays. W. Gentner. Ztschr. f. techn. Physik, 1935, **16,** 416–418; Phys. Ztschr., Dec. 1, 1935, **36,** 810–812. (Reprinted by permission from Science Abstracts, Sect. A, Physics, Jan. 25, 1936, **39,** 35.)

Measurements were made of the change in the absorption coefficients for hard γ-rays of different wave lengths in Pb and of the variation of the absorption coefficient for the hard γ-ray, $h\nu = 2.65$ MV, from ThC″ with absorbers of different atomic number. In both cases good agreement was obtained with existing theory in terms of the three absorption processes involving the photo-electric effect, Compton effect and pair formation.

F. C. C.

Cystic Tumor of the Left Cerebellar Hemisphere and of the Anterior Portion of the Vermis: Post-operative Recurrence—Efficacious Radium Therapy. Angelo S. D'Emidio. Archivio di Radiologia, 1935, **11,** No. 3–4, pp. 231–238.

Professor A. Santoro D'Emidio reports the case of a child, aged 5, who had a recurring cerebellar tumor. A successful result was secured from radium therapy, an improvement which has lasted more than two years. In such cases he recommends light radium therapy repeated at short intervals.

E. T. LEDDY, M.D.

Radium Dosage and Technic in Carcinoma of the Tonsil, Pharynx, and Larynx. Max Cutler. Am. Jour. Roentgenol. and Rad. Ther., May, 1935, **33,** 690–693.

Treating five patients suffering from relatively radioresistant, adult, squamous-cell carcinoma with

radium packs at a distance of from 10 to 15 cm. according to the technic of Coutard, the author has proven that initial sterilization of squamous-cell carcinoma can be effected even though the total time is prolonged over periods varying from 30 to 60 days.

S. M. ATKINS, M.D.

Half-life Period of Radium E. A. Pompéi. Jour. de Physique et le Radium, November, 1935, **6**, 471. 472. (Reprinted by permission from Science Abstracts, Sect. A, Physics, Jan. 25, 1936, **39**, 35.)

The half-life period of Ra E, determined by I. Cuier and Chamié's compensation method, is 5.02 ± 0.01 day.

C. A. S.

Radium Therapy of So-called Radioresistant Epithelioma. W. Schloss and H. Smereker. Strahlentherapie, 1936, **55**, 105.

Epithelioma located in the nasolabial fold, dorsum of the nose, inner and outer corners of the eye, and the ear are assumed to be fairly radioresistant and difficult to treat. At the Municipal Radiation Institute in Vienna, 187 of these cases were seen during the period from 1931 to 1934: 173 were treated and 128 became free from symptoms. Among these were 23 cases which had been treated elsewhere or developed recurrences. The method of treatment consisted of the application of screened radium filtered through 1 mm. Pt. For each case a carefully adapted mold was prepared and applied to the lesion at a distance of a few millimeters. A very small dose per hour was used, the total treatment extending over several days.

The distribution of the dose of radiant energy was determined by means of a Sievert condenser dosimeter; diagrams and tables giving the results of these measurements are shown in the article. One important point is the rapid drop of the intensity with the depth: at 15 mm. below the skin only 18 per cent of the surface intensity was measured. The reactions were relatively mild, undoubtedly because of the protracted application of the dose.

ERNST A. POHLE, M.D., Ph.D.

Pre-operative Radium Treatment of Rectal Carcinoma. Harry H. Bowing and Robert E. Fricke. Am. Jour. Roentgenol. and Rad. Ther., December, 1935, **34**, 766–769.

The treatment of carcinoma of the rectum has proved to be a difficult problem for the surgeon and the radium therapist owing to the relative inaccessibility of the lesion, its usually advanced stage when first seen, and the usual presence of distant metastatic involvement. In some cases, surgery alone, and in others radium treatment alone has resulted in cure.

In cases in which patients present themselves reasonably early, when cure seems possible, more aggressive radium treatment followed after three months or more by surgical excision of the carcinoma, seems the logical procedure.

A preliminary report is given on 58 patients selected for this plan of treatment in the years 1930 to 1933, inclusive. Only 37 of them completed the course of treatment by undergoing radical excision of the growth after radium treatment. Thirty-one of the patients are living at the present time, although two are seriously ill and two others may have residual trouble. The remaining 27 patients appear to be well and free of recurrence. In five of these cases complete healing of the posterior wound has not yet occurred; six patients have been perfectly well for more than four years.

Careful microscopic examination of the removed tissue was carried out in all cases following surgical excision of the growth. In three cases no evidence of carcinoma whatsoever was found in the surgical specimen, radium treatment apparently having destroyed all vestiges of the growth. In three other cases the pathologist found that most of the malignant cells had been eradicated by radium.

S. M. ATKINS, M.D.

ROENTGEN-RAY BURNS AND INJURIES

Contribution to Our Knowledge of Roentgen Injuries. H. Aretz. Strahlentherapie, 1936, **55**, 633.

The author studied the records of all cases of x-ray injuries observed during the last ten years at the Skin Clinic of the University of Bonn. His critical analyses of the causes for these injuries are of interest to all radiologists since in most instances brief clinical data and notes as to dosage are given. From the tables in which the results are compiled it appears that eight injuries occurred in the diagnostic and 44 in the therapeutic field. Twenty-seven of all patients were male and 25 female. The injuries following diagnostic procedures occurred after fluoroscopy of the stomach (5), localization of foreign bodies (2), and roentgenogram of the skeleton (1). The injuries observed in the therapeutic cases were distributed as follows: uterine fibroid (3), sterilization (1), ovarian tumor (1), carcinoma of breast (5), carcinoma of sigmoid (1), tuberculosis of the joint (2), spina ventosa (1), tuberculous gland (8), tuberculosis of the skin (1), lupus vulgaris (2), hypertrichosis (1), tinea (2), psoriasis (3), eczema (12), epidermodysplasia (1). One table lists all cases and gives the diagnosis and degree of injury, information as to whether it was primary, combination or late injury, and its possible cause. It appeared that 22 cases were in all probability due to an error on the part of the physician, five were due to overdosage, three to some action on the part of the patient which aggravated the x-ray reaction, five to some additional factor (for instance, chemical irritant), 15 were unavoidable because of our limited knowledge available at the time of the exposure, one case could not be explained, and in one the original diagnosis of injury had to be changed.

As prophylactic measures the author mentions proper training of the radiologist, strict filter control, and the use of an integrating dosimeter. Injuries due to a combination of factors cannot always be avoided. However, no injury is excusable in diagnostic roentgenology.

ERNST A. POHLE, M.D., Ph.D.

ROENTGEN-RAY DOSAGE

The Biological Measurement of Depth Dosage with 165 kv. and 650 kv. Roentgen Rays. P. S. Henshaw and D. S. Francis. Am. Jour. Roentgenol. and Rad. Ther., December, 1935, **34,** 789–797.

Depth intensity measurements in paraffin were made with 165 kv. and 650 kv. roentgen rays, using wheat seedlings, *Drosophila* eggs, and an ionization chamber. It was found not only that the biological measurements were different from the ionization measurements made, but that the biological measurements differed among themselves at different depths.

When the effect at the surface was taken as 100 per cent, in each case the ionization measurements at points below the surface were found to be above the biological measurements for both 165 kv. and 650 kv.

These results, therefore, indicate the possible error which may be encountered in basing biological depth dosages on measurements made with an ionization chamber. Further, they show how biological responses to radiation may vary when exposed under different conditions.

S. M. Atkins, M.D.

Our Changing Concepts Regarding the Skin Dose, with Some Notes on the Production of Epidermolysis. Walter L. Mattick. Am. Jour. Roentgenol. and Rad. Ther., October, 1935, **34,** 491–496.

The production of the epidermolytic reaction to radiation presupposes an almost complete destruction of the epidermal layers, leaving a relatively intact dermis with vascular and connective tissue elements. This is followed in forty to fifty days after the beginning of treatment by complete restitution through regeneration of the basal layer of cells, some of which have usually survived in islets about the hair follicles and near the edge of the irradiated area. At the State Institute for the Study of Malignant Diseases, Buffalo, N. Y., it has been possible to produce typical examples of this reaction by a single dose of 3,000 r, tissue-measured, or 2,000 r primary roentgen radiation at 23 r per minute rate and 0.11 Ångstrom lambda effective, thus entirely eliminating both protraction and fractionation in its production. Similarly, with 0.16 Ångstrom lambda effective in a single dose of 1,850 r tissue-measured or 1,280 r primary radiation at 65 r per minute, a marked redness followed by severe vesiculation and accompanied by the usual epitheleitis of the mucosa, was produced. The production of the necessary effective saturation or cumulative dose, in accordance with the effective wave length of the radiation used, is of paramount importance, no matter to what limit these total dosage figures may be carried. Such total dosage figures are, therefore, of little importance unless accompanied by factors of total time over which the treatments are carried, daily dose in r, quality of the beam, etc. Epidermolysis similar to that of Coutard was accomplished with 200 kv., 0.5 mm. of copper, 65 r per minute, and 50 cm. skin-target distance, developing 0.16 Ångstrom lambda effective by the administration of 1,300 r skin effective saturation, or 1,960 r tissue-measured radiation in eight days. If alternate neck fields are used every other day for approximately twenty doses over three weeks, it is necessary to go as high as from 3,000 to 3,500 r primary radiation on each field to build up to 1,300 r saturation effective. The daily tissue recovery coefficient is 0.06 plus for the 0.11 Ångstrom lambda effective wave band, and 0.08 for the 0.16 Ångstrom lambda effective wave band (the skin saturation effective of approximately 2,000 r is arrived at for the heavier filtration with 0.11 Ångstrom lambda effective and 1,300 r for the lighter 0.5 mm. copper band primary radiation)

J. E. Habbe, M.D.

ROENTGEN-RAY THERAPY

The Effect of "Coil" Fields in Short Wave Therapy: Temperature Measurements on Several Layers of Electrolytes in the High Frequency "Coil" Field. J. Pätzold and P. Wenk. Strahlentherapie, 1936, **55,** 692.

On the Continent short wave therapy is usually applied by placing the patient in a condenser field, while in this country "coils" have lately been advocated. The authors undertook, therefore, a comparative study of these two methods of application. The experimental procedure is described in detail: coils with one, three, and eight windings were used with wave lengths of 6 and 25 meters. The authors conclude that the "coil" type of apparatus can be used for wave lengths below 10 meters, provided the output of the machine is sufficiently high.

Ernst A. Pohle, M.D., Ph.D.

Further Discussion of the Saturation Method of Roentgen Therapy in Deep-seated Malignant Disease. George E. Pfahler. Am. Jour. Roentgenol. and Rad. Ther., November, 1935, **34,** 629–636.

The author emphasizes the similarity in principle of his "saturation method" and the more recently developed Coutard therapy. He recognizes that some of the older charts constructed show saturation values too low (the curve being too high), although with these older values it has been possible to reach a mild erythema by building up the dosage on this curve and to retain the erythema throughout the later stages of the treatment.

In the application of the saturation method which requires the building up of 100 per cent of an erythema dose in the tumor tissue as soon as possible without producing radiation sickness or damage to the surrounding normal tissues, both surface and depth doses must be carefully determined and in all possible instances cross-firing methods must be used, directing the rays by the side of rather than through essential organs.

Studies were made on mice with transplantable adenocarcinomas. Some of the animals were irradiated with single prolonged exposure, others with simple divided protracted radiation, and still others by the so-called "saturation method." Results showed that the

response of the tumor was less the longer the interval had been between the administration of partial doses, indicating that the influence of divided doses is the same with regard to malignant tumors as with regard to other living tissue, namely, that cumulation is incomplete. In spite of this incomplete cumulation, however, it is not impossible that the therapeutic effect may be better from divided doses than from a single full irradiation. The final conclusions from this experimental study were that in the transplanting of tumors in mice the treatment by protracted fractionated irradiation should be preferred to massive doses, but that the saturation method was definitely superior to simple dividing of the dose.

While one may successfully administer as much as from six to ten erythema doses over the tissues of the neck by the Coutard method (such a quantity of radiation being shown by experimental work of Martin, Quimby and Pack to be necessary for the destruction of cancer tissue), the writer warns against administering more than a total of three or four erythema doses over the abdomen on any one portal because of the great danger of fat necrosis. The same warning would apply to radiation over the lungs, heart, intestines, liver, or the spleen. A saturation curve for 200 kv., 0.5 mm. copper plus 2 mm. aluminum, and tables of equal erythema reactions following different percentages of erythema doses administered daily are included.

J. E. HABBE, M.D.

Neoplasms of the Oral and Upper Respiratory Tracts Treated by Protracted Roentgen Therapy. William Harris. Am. Jour. Roentgenol. and Rad. Ther., October, 1935, **34,** 482–490.

The writer reiterates the principles of Coutard's roentgen therapy and condemns those modifications which various other workers have introduced merely for economy of time and expense. Only the very sensitive tumors such as the lymphosarcomas and the undifferentiated epitheliomas may be directly destroyed by the action of the radiation on the tumor cell. In the highly differentiated tumors such as epidermoid epithelioma with prickle cells predominating or tubular adenocarcinoma, the cure is effected only by evolution (that is, by slow saturation effects of these cells by radiation, thus hastening their maturation and death), and it is, therefore, understandable why every effort must be made to preserve the integrity of the tumor bed of vasculo-connective tissue. When, on the other hand, this bed tissue is also destroyed marked skin and mucous membrane changes are apt to occur with late radionecrosis.

Preliminary to instituting Coutard therapy every patient is given a complete physical examination including blood studies and such roentgen examinations as indicated, a biopsy, and a dental examination followed by the extraction of all decayed and infected teeth. To maintain nutrition the patient is given a high caloric diet and high fluid intake. Preliminary blood transfusion will help if there has been considerable blood loss. Preliminary tracheotomy is done only when there is immediate danger of complete obstruction. Smoking and alcoholic intake are contra-indicated in intrinsic and extrinsic neoplasms of the larynx during the treatment and the reaction stages. Anesthetic sprays and tablets, coal tar products, codein, barbitols, and normal saline mouth washes are prescribed freely as indicated. The writer's treatment factors are: 180 kv. constant potential or 200 kv. pulsating; 3 to 4 milliamperes, with a filter of 2 mm. copper plus 2 mm. aluminum; focal skin distance from 50 to 60 cm.; portals 80 to 150 sq. cm.; 75 to 100 r per field during the first three or four days to avoid what may be called acute sensitization of the neoplasm to the radiation. If there is no undue reaction after three or four days, 200 r measured with back-scattering is given to each of two fields daily (except Sunday) until from 3,000 to 4,000 r per field, measured with back-scattering, has been given over about 30 days. Boric ointment or nupercaine may be used to alleviate the itching and pain of the radiodermititis.

The difficulty of making a prognosis from the size of the lesion, anatomical site, and histological configuration of the biopsy specimen is stressed. External irradiation alone cannot control the majority of extensive intra-oral malignancies, hence intrinsic radium therapy or surgical endothermy are essential as supplementary treatment. The results of 26 cases of extensive intra-oral and laryngeal carcinoma treated by the above outlined procedures are given.

J. E. HABBE, M.D.

A Case of Dercum's Disease and its Treatment by Deep X-rays. Stephen K. Montgomery. British Med. Jour., Feb. 22, 1936, No. 3,920, pp. 357, 358.

The author reports the case of a married woman, 50 years of age, who complained of continuous intense pains in her legs of five years' duration, and generalized obesity of the legs of 18 years' duration. Three months after the birth of her third child in 1914 she suffered from post-puerperal melancholia and her weight fell to 100 pounds. In 1916 she began to recover and in 1918 her present state of obesity began. For the last five years she had suffered intense pains in her legs. Her weight at the time of this examination was 240 pounds. Of interest was the persistence of secretion in the breasts, apart from pregnancy. An indefinite history of protrusion of the eyes and tremor of the hands was obtained.

The diagnosis of Dercum's disease (adiposis dolorosa) was made. While this condition was originally considered to be related to the thyroid gland, it has recently been established that it is dependent upon some morbid condition of the pituitary gland.

The result of irradiation therapy of Fröhlich's syndrome have been variable and in those cases in which improvement resulted the effect was believed to be due to reduction in size of the tumor and thus reduction of pressure on the pituitary, rather than to any effect on the pituitary itself. Good results were obtained in the irradiation therapy of Cushing's syndrome, basophile adenoma. No reports of irradiation therapy of

this condition were found in the literature. However, treatment was given to the reported case at eight weekly intervals, employing the following factors: 200 kv. p., 4 ma., 6 × 8 cm. fields, 0.8 mm. Cu + 1 mm. Al filtration, right and left fields alternately. Four treatments of 140 r each were given to each port.

The results of the above treatment were considered good as the pain improved after the second treatment and eventually disappeared. The size of the patient's legs was believed to be reduced to some extent.

J. N. Ané, M.D.

Roentgen Therapy of Thrombo-angiitis Obliterans (Buerger's Disease). G. E. Pfahler. Am. Jour. Roentgenol. and Rad. Ther., December, 1935, **34,** 770–777.

After reviewing the histology, etiology, symptoms, and treatment with results of other authors, the writer states that his patients showed definite improvement of every symptom. The technic consisted of 200 kv. therapy, applied over the sympathetic ganglia, indicated by the location of the disease, three times a week until a total of one-half to a full erythema dose had been given over each portal or over the whole area.

Pain was relieved usually in about two or three weeks after the inception of treatment; intermittent claudication in from two to six weeks; circulatory and trophic disturbances in from four to six weeks, so that the normal color reappeared although the pulse did not return. Ulcerations disappeared within a few months, gangrene healed, general improvement was rapid, and the cachectic color disappeared.

S. M. Atkins, M.D.

The Desensitization of the Mucous Membrane during Protracted Fractional Roentgen Therapy. R. Glauner. Strahlentherapie, 1936, **55,** 195.

The severe reactions produced in the mucous membranes of the mouth following x-ray therapy applied according to the Coutard method are often very uncomfortable to the patient. The author undertook experiments directed towards an attempt at desensitizing the mucosa in order to reduce the subjective symptoms. In eight cases of carcinoma of the floor of the mouth he applied adrenalin (1:1000) before each sitting to *one* side of the buccal mucosa; the non-medicated side served as control. In five cases treated in this manner the radio-epithelitis did not appear at all. In two cases it was considerably decreased and one case could not be considered because no reaction appeared on either side. The beneficial effect of adrenalin is, according to the author, due to the local anemia.

Ernst A. Pohle, M.D., Ph.D.

THE SINUSES

Mucocele of the Frontal Sinus, with Special Reference to the Roentgen Aspects and Report of Four Cases. Adolph Hartung and Theodore Wachowski. Am. Jour. Roentgenol. and Rad. Ther., July, 1935, **34,** 30–36.

A mucocele is an accumulation and retention of a mucous secretion within a nasal accessory sinus, usually associated with distention of one or more of its walls. The usual causative factors are obstruction of the nasofrontal duct or enlargement of a retention cyst. It occurs at any age. A history of trauma is often elicited. Early symptoms are varied but later findings of a slow-growing, non-tender tumor in the medial upper third of the eye with displacement of the globe forward, downward, and laterally are characteristic.

Roentgen findings in connection with mucocele of the frontal sinus vary according to the stage of development of the condition. The most characteristic findings are enlargement of the sinus with pressure erosion of the walls, resulting in increased radiolucency, and displacement of the boundaries, causing distortion of outline. Reactionary bone formation may be present.

S. M. Atkins, M.D.

THE SKIN

Influence of Roentgen Rays on Skin Capillaries. A. Löw-Beer and W. Redisch. Strahlentherapie, 1936, **55,** 85.

Small fields in human skin were exposed to roentgen rays according to the single massive, fractional, saturation, and protracted fractional dose methods. Photographs of the skin capillaries in the irradiated areas were taken at various intervals following the exposures (32 illustrations). It appeared that following the application of one single massive dose the reaction started in the subpapillary plexus. Following saturation a severe but rapidly disappearing reaction was seen in the capillary system. The protracted fractional exposure produced the mildest reaction.

Ernst A. Pohle, M.D., Ph.D.

The Reaction of the Skin to Roentgen Rays of Long Wave Length and to Cathode Rays. E. Wilhelmy. Strahlentherapie, 1936, **55,** 498.

The author studied the erythema reaction of the human skin to roentgen rays produced at from 2.5 to 15 kilovolts. He found that the reaction consisted of an early erythema appearing within eight days after the exposure and a second or principal erythema appearing from three to four weeks after the exposure. The threshold doses for the early erythema increase with increasing wave length. In one person, for instance, it was found at 80 r with 12 kv. and at 4,000 r with 2.5 kv. The respective values for the principal erythema were 600 r at 9 kv. and 20,000 r at 3 kv. Fifteen hundred r at 12 kv. may produce telangiectasis; photographs of a patient's arm are shown in the article as evidence. Similar studies were carried out with cathode rays. However, even after exceeding the threshold erythema dose four hundred times there appeared no late reaction. One skin area could be studied for a period of three and a half years. This phenomenon is explained with the very short length of path of the cathode rays.

Ernst A. Pohle, M.D., Ph.D.

THE SPINE

A Case of Congenital Aplasia of the Sacrum. J. H. Müller. Röntgenpraxis, February, 1936, **8,** 105, 106.

Twenty cases of aplasia of the sacrum have been reported in the literature. Such a case is described. The first sacral vertebra is partially developed and articulates in normal fashion with the pelvis. What would normally constitute the remaining sacrum is entirely absent.

HANS W. HEFKE, M.D.

Changes in the Posture Due to Diseased Intervertebral Discs and Their Relation to Backache. Eduard Güntz. Röntgenpraxis, February, 1936, **8,** 73–87.

Diseases of the intervertebral discs can only be diagnosed when there are secondary changes of the vertebral bodies demonstrable on roentgenograms, or if calcification or ossification of the disc itself has taken place.

The author has shown that an abnormally straight posture may be found in the portions of the spine which are situated above certain diseases of the disc, changes which are similar to the ones described with fractures, spondylitis, and congenital anomalies. It is suggested that particular attention should be paid to changes in posture, clinically, as well as roentgenologically. For that reason, the roentgenograms, especially the lateral ones, are made with the patient standing up and from as great a distance as possible.

In some patients who complain of backaches, such an abnormally straight posture may be found without other changes in the spine. It remains constant even when bending forward, and usually comprises a circumscribed portion of the lower dorsal spine. The abnormal straightness is seen when the vertebræ are displaced posteriorly, which may happen only after damage to the discs, and in cases of osteocondrosis of the disc. This pathologic straightness without bony changes is, therefore, considered a sign of changes of the intervertebral disc. It is best explained by an increased tonus of the muscles of the back, which are used as an auxiliary brace for the pathologic portion of the spine.

In many healed processes (juvenile kyphosis, fractures, tuberculosis, etc.) which by themselves would cause no symptoms, pains may be localized above the lesion and in the area of abnormal straightness.

These observations seem to indicate that such late symptoms after the primary disease has healed are pains due to the lordosis. The same holds true in diseases of the intervertebral discs. They are pains from muscles and the periosteum and they may be also from ligaments and small joints.

Several times a calcification of the annulus of the disc could be seen in the region of the abnormal lordosis. These calcifications are probably due to the unusual tension on the disc, which stimulates the deposition of calcium salts.

HANS W. HEFKE, M.D.

Spina Bifida Occulta. W. Weiss. Zentralbl. f. Chir., Sept. 28, 1935, **62,** 2295–2300. (Reprinted by permission from British Med. Jour., Dec. 7, 1935, p. 88 of Epitome of Current Medical Literature.)

The author points out that systematic x-ray examinations have recently established the comparative frequency of spina bifida occulta, the first sacral vertebra being involved in 50 per cent, according to Speranski. This condition is frequently the cause of root pains after overwork or acute strain in young adult manual laborers. Not infrequently a lipoma, myofibrolipoma, dermoid cyst, or angioma in the vertebral canal is connected by a pedicle with a second similar tumor lying partly beneath the skin and partly in the cleft of the neural arch. In spina bifida the spinal cord may lie lower in the vertebral canal than is usual, and the resulting tension may cause referred symptoms. A case is described in a female factory worker, aged 20, thought to have spondylitis. Spina bifida occulta was suspected from the characteristic dimple, local hypertrichosis, and absence of palpable second and third lumbar spinous processes, but, even after confirmatory x-ray examination, a causal connection with the spastic paraplegic symptoms was denied, because the associated root pains and hyperesthesia corresponded to the second lumbar segment normally lying at the level of the tenth and eleventh dorsal vertebræ. Lipiodol injection showed a stop at the level of the bony hiatus, and led to laminectomy and partial removal of a lipoma extending from the first to fourth lumbar vertebræ and infiltrating the spinal cord. Much improvement followed.

A Contribution to Our Knowledge of the Fissure and Gap Formation of Atlas and Epistropheus. P. Geipel. Fortschr. a. d. Geb. d. Röntgenstrahlen, 1935, **52,** 533–570.

This excellent anatomic study contains the following chapters:

(1) A publication of 56 additional new cases of posterior fissure or gap formation of the atlas, also absence of a neural arch on one side, lateral and double fissure and gap formation in anterior and posterior arches. Furthermore, the closure of the gap is discussed.

(2) A discussion of the osseous formation of the anterior arch from mono- and binuclear anlage, in cases of absence of anterior nuclear anlage by growth of the lateral masses. Aside from normal development the numerous variances are discussed. The closure of the posterior arch during the first decade of life is illustrated, and also the fibrous bridge-formation of gaps and fissures, especially in thoracopagi. Illustrations are also given of partial displacement of the posterior arch on the epistropheus.

(3) In 20 per cent of all newborn accessory nuclei of ossifications are found between the body and the roots of the neural arches of the epistropheus. The development of the "terminal ossicle" in the cephalic tip of the odontoid process is illustrated and posterior fissure and gap formation of this second cervical vertebra in earlier stages of development is shown.

The clinician regrets the absence of any remarks concerning the significance of many of these deficiencies for good function and clinical well-being.

H. A. JARRE, M.D.

Kyphosis Juvenilis (Scheuermann's Disease). H. Scheuermann. Fortschr. a. d. Geb. d. Röntgenstrahlen, 1936, **53,** 1–16.

Kyphosis juvenilis exists most frequently in two or three vertebræ. The most apparent changes usually involve the anlage and development of the so-called limbus vertebralis as follows: The anlage of the limbus may be entirely missing. It is normally located close to the anterior edges of the vertebral body but in the presence of disturbances it not infrequently fails to reach the level of the anterior margin of the vertebral body; its form may undergo abnormal changes. The disease rarely antedates by several years the anlage of the limbus. As a result of juvenile kyphosis the affected vertebra assumes a wedge-shaped disfiguration. One may consider this deformation as a compression of the ossified spongeous body, combined with a retardation of growth. In addition, a prolapse of nucleus pulposus may be observed.

The prognosis of the disease never can be given reliably at the beginning of the affliction. Fixation of the kyphosis can occur within six months' time. The ultimate deformity of the vertebral body corresponds to the degree of the kyphosis. The earliest wedge shaped deformity with subsequent kyphosis was observed in a boy nine years of age before demonstrable anlage of the limbus.

Nucleus pulposus prolapse never was found in animals under normal conditions.

H. A. JARRE, M.D.

Treatment of Spondylo-arthritis Ankylopoietia by Exercising. C. Keiffenheim. München. med. Wchnschr., Feb. 28, 1936, **83,** 358, 359.

In a review of a large series of cases of Bechterew's disease, the author shows the efficacy of prescribed exercises in the prevention of complete loss of articular motion and relief of concomitant pain. Early diagnosis is the most essential factor and symptoms suggestive of the condition are dull, continuous backpain, with stiffness and restricted motion of the vertebral column. These symptoms indicate the need for a roentgenographic examination. Such an examination may show pathognomonic evidence of the disease, with thickened or ankylosed sacro-iliac synchondroses; beginning ossification of the paravertebral ligaments and periosteal proliferation along the innominate bones. Increased blood sedimentation time is significant. Roentgenoscopically marked restriction of respiratory movements is noted very early in the disease.

WILLIAM R. STECHER, M.D.

Fractures of the Spine. S. T. Irwin. British Med. Jour., Jan. 4, 1936, No. 3,913, 1–5.

The author reviews a series of 34 cases of fracture of the spine which were treated in the Royal Victoria Hospital, Belfast, during the period from 1931 to 1934. The sites of fracture were as follows: Cervical region, three cases; upper dorsal and mid-dorsal, two; lower dorsal, ten; lumbar, seventeen, and coccyx, two. All cases of fracture of a body in this series were treated by the method of Watson Jones. The results obtained in this series were as follows: Death occurred in four cases during the first nine days after the injury; one patient died of cancer of the stomach two and one-half years after injury; one patient is paralyzed; 14 patients suffer from pain of varying intensity, and 18 patients are able to do full work.

Direct violence, indirect violence, and muscular violence are all operative in the causation of fracture of the spine. The preponderating cause, however, is that of indirect violence.

Fracture of the atlas results from the transmission of a force through the occipital condyles to the lateral masses. Due to the inclination of the articular facets of the atlas the effect of the transmitted force is to spread the lateral masses outward. This results in fracture of the posterior arch which is weaker than the anterior. Both arches may be involved at times. Anteroposterior and lateral films are of great value in the diagnosis.

The base of the odontoid process is the most frequent location of fracture of the axis. Fractures and fracture dislocations of the cervical spine below the axis are divided anatomically into those above the fourth cervical and those below this level. Injuries above the fourth cervical with cord lesions result in death from respiratory failure. Those injuries with cord lesions are usually pure dislocation and are easily diagnosed radiologically. In injuries below the fourth cervical associated with cord lesions, immediate death does not usually occur, but paralysis usually results.

Compression fracture of a vertebral body is the most frequent type of spine fracture. The majority of these occur in the dorso-lumbar region. While the fracture may be complicated, in the majority of cases injury is confined to the vertebral body. After injury the body becomes wedge-shaped, with the narrow portion anteriorly, because the posterior portion is better protected by the articular processes.

Fractures of the spinous processes and laminæ are due to direct violence. Fractures of the transverse process are due to muscular violence. They are unilateral and multiple and always occur in the lumbar region.

J. N. ANÉ, M.D.

THE STOMACH

Gastric Polyp and Anemia. Josef Pinke. Röntgenpraxis, December, 1935, **7,** 793–797.

Polyps of the stomach may cause a blood picture very similar to that of pernicious anemia. A case which is described suffered from a rather severe degree of anemia and other symptoms of pernicious anemia. A roentgen examination of the stomach showed a polyp the size of a kidney bean in the pylorus and at other

times in the duodenum. Surgical resection showed a benign adenomatous polyp. The author maintains that not only the chronic hemorrhage from the polyp but also the disturbed cellular structure of the stomach must be considered as a causative factor for the anemia.

HANS W. HEFKE, M.D.

SYPHILIS

Tabetic Arthropathy and Accident. Robert Kienböck and Alfred Selka. Röntgenpraxis, February, 1936, **8,** 120–124.

It has been known that tabetic joints develop either spontaneously or after injuries. A case of a man is described, who, after falling 15 feet, suffered dislocations of both hips, which were reduced. Considerable difficulty in walking remained. Four years after the accident an x-ray examination showed very marked destructive changes in both joints, and calcifications in the soft tissues. The roentgen diagnosis was tabetic arthropathy. The patient admitted syphilitic infection in his youth, but there were no neurological symptoms of tabes demonstrable. The joint changes were, therefore, early symptoms of the tabes.

In case of compensation proceedings one would have to say that the accident was the primary cause for the joint changes, but that these changes developed so fast and so severe that they can be explained only by the pre-existing syphilitic disease.

HANS W. HEFKE, M.D.

THE TEETH

X-ray Absorption Coefficients of Coronal and Root Dentin. Franklin Hollander and Edmund Vesely. Proc. Soc. Exp. Biol. and Med., March, 1936, **34,** 158, 159.

Linear x-ray absorption coefficients were measured in various parts of the dentin of four non-carious human teeth from different individuals. It appeared that the coefficient approached an upper limit in the coronal dentin of non-carious teeth and that the deviation from the maximum value tended to increase with the distance between the position of measurement and the dentino-enamel junction. Dentin formation is known to start at this junction and to proceed toward the root apices. Thus, the gradient in the x-ray absorption coefficient of the dentin appears to parallel the progress of its formation.

W. A. SODEMAN, M.D.

THE THYROID

Results in Roentgen Therapy of Basedow's Struma with a Modified Protracted Treatment Method. W. Böhme. Strahlentherapie, 1936, **55,** 262.

During the last few years the author has tried a modified protracted fractional dose method in the treatment of thyrotoxicosis. He used 180 kv., 1 mm. of Cu + 1 mm. Al, H.V.L. in copper, 1.35 mm., 60–70 cm. F.S.D., 4.35 r per minute (in air) on three successive days. A dose of 150 r was applied over the thyroid and upper sternum. The total dose given in several series during a period of from four to eight weeks amounted anywhere from 1,800 to 2,000 r. There were no systemic or skin reactions, so that the author feels that from 1,200 to 1,600 r can be given in from four to six weeks. From 1932–1934, a total of 91 patients were subjected to irradiation with this method; six died in the meantime but the cause of death was not connected with radiation therapy. In evaluating the results of the treatment, all factors, as, for instance, the basal metabolic rate, pulse rate, weight, and subjective symptoms were considered. Eighty-one cases were available for statistical evaluation. It appeared that 81 per cent of all cases were clinically cured. The period of observation varied from six months to two and one-half years. A comparison with the results obtained by the old treatment methods showed definite superiority of the modification described above.

ERNST A. POHLE, M.D., Ph.D.

THE TONSILS

Roentgen Therapy of Tonsilitis. E. D. Dubowyi and E. I. Olschanowskyi. Röntgenpraxis, February, 1936, **8,** 112–115.

This is the second communication on this subject. Patients to the number of 700 have been treated; 254 are reported in both communications. All these patients have been observed twice a year for from one to three years after x-ray therapy for tonsillitis. The technic of irradiation was as follows: 210 kv., 4 ma., a filter of 0.5 mm. Cu and 2 mm. Al. and a skin-focus distance of 25 cm. In children up to five years of age, 20 per cent of an erythema dose was given; from five to ten years of age, 25 per cent; from 10 to 15 years of age, 30 per cent, and in older persons, $33^1/_3$ per cent (erythema dose, 640 r). Usually one or two treatments to each tonsil are sufficient. The percentage of cures in tonsillitis is 72 per cent after roentgen therapy.

This percentage did not decrease after a year or two. The roentgen therapy of chronic and recurrent tonsillitis decreases markedly the loss of time due to sickness caused by tonsillitis. Complications during and after treatments have not been observed.

HANS W. HEFKE, M.D.

The Combined Treatment of Carcinoma of the Tonsils. P. v. Kisfaludy. Strahlentherapie, 1936, **55,** 429.

The author advocates the combined surgical, x-ray, and radium treatment of carcinoma of the tonsil. He implants radium needles of 2–3 cm. length which remain only from one to one and a half days *in situ*. The cervical areas receive roentgen deep therapy prophylactically (6 − 8 × 200 r); if the glands are enlarged they are removed surgically followed by x-ray therapy (10 − 18 × 180 r). In case of definite metastases in the cervical glands, they are radically resected if still in the operable stage. Radium screens are placed then in the wounds and later x-ray therapy is also given. The palliative results with this treatment method were satisfactory. During the last three and one-half years

a total of 40 inoperable cases belonging to this group were treated. Sixteen were alive and free from symptoms at the time of writing the report. They had been under observation for from one to 38 months. The author recommends, therefore, his combined method as outlined above in the treatment of inoperable carcinoma of the tonsils.

ERNST A. POHLE, M.D., Ph.D.

TUBERCULOSIS, PULMONARY

Selective Serial Bronchography for the Diagnosis of Tuberculous Changes of the Bronchi. Pedro L. Fariñas. Fortschr. a. d. Geb. d. Röntgenstrahlen, 1936, **53**, 17–24.

This well illustrated paper shows the variety of bronchial changes which occur in the course of tuberculosis and which are demonstrable only by the introduction of a suitable contrast medium. Generally speaking, one may find pathologic narrowings and widenings of the bronchial lumina. Narrowing may be produced by extrinsic pressure, cicatrization, intrinsic pathologic contents, and granulation tissue; widening may be of all types, shapes, and varieties—cylindrical, sacular, and vesicular. It is very apparent that important information concerning structure and function of the bronchi can be obtained by this method, which, as stated in the paper, may have to be supplemented frequently by bronchoscopic exploration.

H. A. JARRE, M.D.

A Further Contribution to the Roentgen Therapy of Pulmonary Tuberculosis. G. Cola and G. Grado. Archivio di Radiologia, 1935, **11**, No. 3–4, pp. 249–279.

After a review of the literature on the roentgen treatment of pulmonary tuberculosis, the authors describe their experience with about a hundred cases they have treated by irradiation of the spleen, by direct treatment of the lungs, and by treatment of the spleen and lungs combined.

They prefer the latter method and feel that roentgen therapy combined with pneumothorax is the best method of treating pulmonary tuberculosis. Roentgen therapy is indicated in the proliferative fibrotic and glandular types, in which it gives brilliant results.

E. T. LEDDY, M.D.

Pathology of Childhood Tuberculosis. Chester R. Brown. Jour. Med. Soc. of New Jersey, February, 1936, **33**, 77, 78.

The author traces the pathology of childhood tuberculosis in the respiratory tract through the stages of primary, solitary pulmonary focus, perifocal inflammation, and lymphatic spread. He describes the x-ray findings in these various stages and stresses the technical and anatomical difficulties of x-ray diagnosis. He concedes that thoracic lesions are diagnosed in only 20 per cent of positive Mantouxs, and, therefore, serial plates as well as close co-operation between the roentgenologist and the physician in charge of the case are recommended.

W. H. GILLENTINE, M.D.

TUMORS (DIAGNOSIS)

Roentgen Diagnosis of Malignant Duodenal Tumors. Zoltan von Hrabovszky. Fortschr. a. d. Geb. d. Röntgenstrahlen, 1935, **52**, 580–594.

This paper is based on the observation of three carcinomas and one sarcoma of the duodenum. It gives a very interesting review of the literature and arrives at the following conclusions:

(1) Carcinoma of the papilla of Vater can be demonstrated roentgenologically before a stenosis occurs.

(2) Infiltrating neoplasms transform the duodenum into a rigid tube which, in case of carcinoma, shows a rather irregular, ragged narrowing for a short distance; in cases of sarcoma, usually for a longer stretch. With advancing growth of the tumor the lumen may later enlarge. It appears that infiltrative neoplasms produce stationary longitudinal duodenal folds, while superficial infiltration of the mucosa produces a coarse, stationary transverse formation of folds; in both types of tumor the normal, very characteristic and active duodenal motility, with the perpetual change in the apparent relief, is changed to a frozen appearance.

H. A. JARRE, M.D.

Cholesteatoma. Lewis J. Friedman. Am. Jour. Roentgenol. and Rad. Ther., July, 1935, **34**, 37–40.

Three cases are presented, two of which have been verified by the pathologist. This pearly tumor is a rare, benign, squamous-cell, epithelial neoplasm usually containing cholesterin crystals. This tumor is fairly frequent in the mastoid. Microscopically, the tumor is composed of flattened epithelial cells mixed with cholesterin crystals.

Roentgenologically it appears as a punched-out area of decalcification in the skull, polycystic, with dense trabeculæ between the cysts, and well circumscribed. It is invasive, but does not expand the tables of the skull.

The growth of this lesion is insidious and produces symptoms by mechanical pressure when it occurs in the skull. In the mastoid it produces a persistent aural discharge.

S. M. ATKINS, M.D.

Deep Roentgen Therapy of Carcinoma of the Bladder and Prostate. A. T. Nisbet. Am. Jour. Roentgenol. and Rad. Ther., June, 1935, **33**, 807–809.

The large majority of the cases of carcinoma both of the bladder and the prostate referred for roentgen therapy were in advanced inoperable stages of the disease. A number of the patients were unable to complete a course of x-ray treatment and died within three months of being first seen.

Concerning technic of radiation, the author notes that this has varied somewhat in recent years. The older technic utilized 190 kv., and 1 mm. copper, whereas during the last nine months as much as 3 mm. Cu and 250 kv. have been utilized. The increase in roentgens delivered to the skin has risen from 1,200 r in the earlier days to 2,000 r with the heavier filtration and

higher voltage. Ports of entry include one perineal, two iliac, and two gluteal. If it becomes apparent that the patient is obtaining some relief and there is a possibility of further benefit, a second course of treatments is given about three months after the first. Concerning roentgen sickness, the writer has found that 2 c.c. of liver extract given two or three times a week is almost a panacea for undesirable reaction.

The frequency of urinary infection in these cases is stressed and emphasis is placed upon systematic effort to control or at least to minimize it.

While results on the whole were far from brilliant, the writer found a number of patients responding to the extent that they obtained relief of pain and at times of the symptom of frequency. (A note is also made of a small series of eight cases of benign prostatic hypertrophy which were also submitted to deep x-ray therapy, all being relieved of symptoms and considered well at the time of this report.) The writer concludes with a plea for more routine pre-operative radiation of these cases.

J. E. HABBE, M.D.

Sialography, with Particular Reference to Neoplastic Diseases. H. T. Kimm, J. W. Spies, and J. J. Wolfe. Am. Jour. Roentgenol. and Rad. Ther., September, 1935, **34**, 289–296.

Sialography of 18 cases is presented in which a tumor occurred in the region of the salivary gland and in which a pathologic diagnosis was recorded.

The technic consisted of the injection of from 1 to 1.5 c.c. of an opaque oil by means of a 2 c.c. Luer syringe and cannula, the latter inserted into the duct, until slight discomfort was experienced in the salivary gland. The roentgen examination is made immediately after the injection. The cannula and syringe may or may not be left in place. The discomfort disappears within a few hours.

By means of this examination, in that the entire gland with its ducts could be visualized, it was possible to localize the involvement and its extent, although it could not be determined whether it was benign or malignant.

S. M. ATKINS, M.D.

The Roentgenologic Diagnosis of Tumors in the Sellar Region. Bernard H. Nichols. Am. Jour. Roentgenol. and Rad. Ther., June, 1935, **33**, 733–735.

Fortunately for the accuracy of x-ray diagnosis most tumors in the sella and its immediate neighborhood produce rather typical changes on the roentgenogram. There are, however, certain sellar lesions accompanied by early eye changes and clinical evidence of tumor in which no definite changes in the bony structures of the sella occur. Encephalography is definitely indicated in the suspected presence of suprasellar lesions or intrasellar lesions when there is some question as to the presence of the tumor, from plain film roentgen examination.

Of twelve cases of suprasellar tumor reviewed in this series, two showed calcification and one showed definite sellar changes. Of the remaining nine, encephalography was utilized and in seven of these the tumor was either visualized or a deformity of the ventricle was demonstrated, usually the third ventricle and of the basilar cistern. In the remaining two cases the encephalogram failed to indicate the presence of the tumor. The important encephalogram findings are: (1) complete or partial obliteration of the cisterna chiasmatis; (2) elevation of the floor of the third ventricle or encroachment on its anterior portion; (3) separation of the anterior horns of the lateral ventricle, and (4) visualization of the tumor mass by the surrounding air in the basilar cisterna and third ventricle.

There were twelve intrasellar lesions, eleven being pituitary adenomas and one a medullary blastoma. Encephalography is seldom necessary in making a diagnosis of intrasellar tumor, which usually produces sufficient sellar deformity or calcification to make a diagnosis on the plain roentgenogram.

J. E. HABBE, M.D.

TUMORS (THERAPY)

Giant-cell Bone Tumor of Costal Origin. Paul C. Samson and Cameron Haight. Jour. Am. Med. Assn., Sept. 28, 1935, **105**, 1020–1023.

In reporting a case of giant-cell tumor involving the second rib, proximal to the costochondral junction, on the right, these authors present clinical abstracts of seven of the nine other cases of giant-cell tumor of the rib that have been collected. In four cases the tumor was posterior to the costal angle. In two, the entire first rib was apparently involved, and in two the tumor was at the costochondral junction. Surgical excision was done in six cases, irradiation in one, and partial excision and irradiation in one other.

At present it appears that irradiation is the treatment of choice if the diagnosis can be established with certainty. Conspicuous deformity may indicate the surgical removal of the tumor. In the reported series no case of recurrence has been found, whether treatment was by surgical excision, irradiation or both. The prognosis for cure, therefore, should be good.

CHARLES G. SUTHERLAND, M.B. (Tor.)

Studies Regarding the Effect of Roentgen Rays on the Metabolism of Malignant Tumors. K. Inouye. Strahlentherapie, 1936, **55**, 409.

The author studied the metabolism of an implanted spindle-cell sarcoma in the rabbit before and after irradiation. Two different wave lengths of roentgen rays were used: Half value layer in copper, 0.1 mm., for a filter of 1.0 mm. Al, and half value layer in copper, 0.36 mm., for a filter of 0.3 mm. Cu + 1.0 mm. Al; 600 and 1,200 r. The influence of the irradiation on the metabolism seemed directly proportional to the dose; a minimum of 600 r was required to make any change demonstrable. Numerous curves are shown which indicate the fluctuations in the metabolism of the tumor cells over a period of several days. The author believes that the changes in the metabolism of the irra-

diated tumor tissue are due to an injurious effect of the roentgen rays. The metabolism after irradiation approaches that observed in tissue undergoing degeneration.

ERNST A. POHLE, M.D., Ph.D.

Experiments in the Combined Roentgen and Heat Therapy of Malignant Tumors. Kristian Overgaard. Acta Radiologica, 1935, **16,** 461–470.

The author presents experimental evidence, obtained by work on white mice, to show that diathermy and roentgen radiation may be effectively combined in such a way for the treatment of malignancies that subtherapeutic doses of the two may have an additive, complementary effect, producing an electric, tumorcidal result.

E. M. SHEBESTA, M.D.

ULTRA-VIOLET LIGHT

Studies of Protective Ointments for Ultra-violet Radiation and Related Principal Problems. J. M. Eder and L. Freund. Strahlentherapie, 1936, **55,** 560.

The authors undertook an extensive investigation of ointments available as protection against the erythema producing rays of the sun and artificial sources of ultra-violet light. They come to the conclusion that biologic tests are not reliable. They consider the entire range from 2,300 to 3,950 Å. as effective on the skin. The maximum erythema effect in the quartz mercury vapor lamp is between 2,970 and 3,130 Å., for the sun between 3,000 and 3,500 Å., and for the carbon arc between 3,000 and 3,950 Å. A preparation called "Antilux" appeared to be superior to all other investigated ointments; it provides sufficient protection for ultra-violet rays from 3,100 to 3,500 Å. This ointment also reflects radiation around 3,130 Å.

ERNST A. POHLE, M.D., Ph.D.

THE UTERUS

The Changes in the Blood of Women with Cancer of the Uterus after the Use of Vaccine Broth and Radium and X-ray Treatment. A. M. Bonanno. Archivio di Radiologia, 1935, **11,** No. 3–4, pp. 325–344.

Administration of vaccine tends to diminish the infection present in the cervical carcinoma and thereby the leukocytosis of the patient is reduced. During radium treatment the red cell count tends to improve, the white cells to behave in a varying way. After the vaccine, the polymorphonuclear cells tend to decrease. After combined radium and X-ray treatment there is a decrease in the leukocytes and to a less extent in the erythrocytes and hemoglobin. Shortly the blood returns to normal. Changes in the blood, by themselves, seem to have no definite prognostic significance as they are changes secondary to the uterine cancer.

E. T. LEDDY, M.D.